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ABSTRACT

The two student notebooks in this set provide the basic course outline and assignments for the second year of a four year senior high school unified science program. The two volumes contain these four units: Expansion of Ideas About the Nature of Matter, Characteristics of Living Matter, Mechanisms of Life Processes, and Patterns of Change. The major portion of the first unit is devoted to basic chemistry; and the unit on patterns of change involves lessons and activities in heredity, population dynamics, and evolution. The materials in the notebook for each of the sub-units include: a list of required and recommended readings from various other books; questions for consideration in introducing a lesson; a brief background reading; a basic outline of the lectures with space provided within the outline for notes; laboratory activities and investigations; laboratory problem reports and other kinds of assignments (discussion questions, completion questions, problems); and summary statements and review questions. Numerous diagrams and illustrations are included. (PR)

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Wisconsin State Department of Education

ED0 53982

SCIENCE

MATTER-ENERGY INTERACTIONS RELATING TO LIFE ON EARTH

CHANGE

MATTER
ENERGY
TIME

NAME ______________________

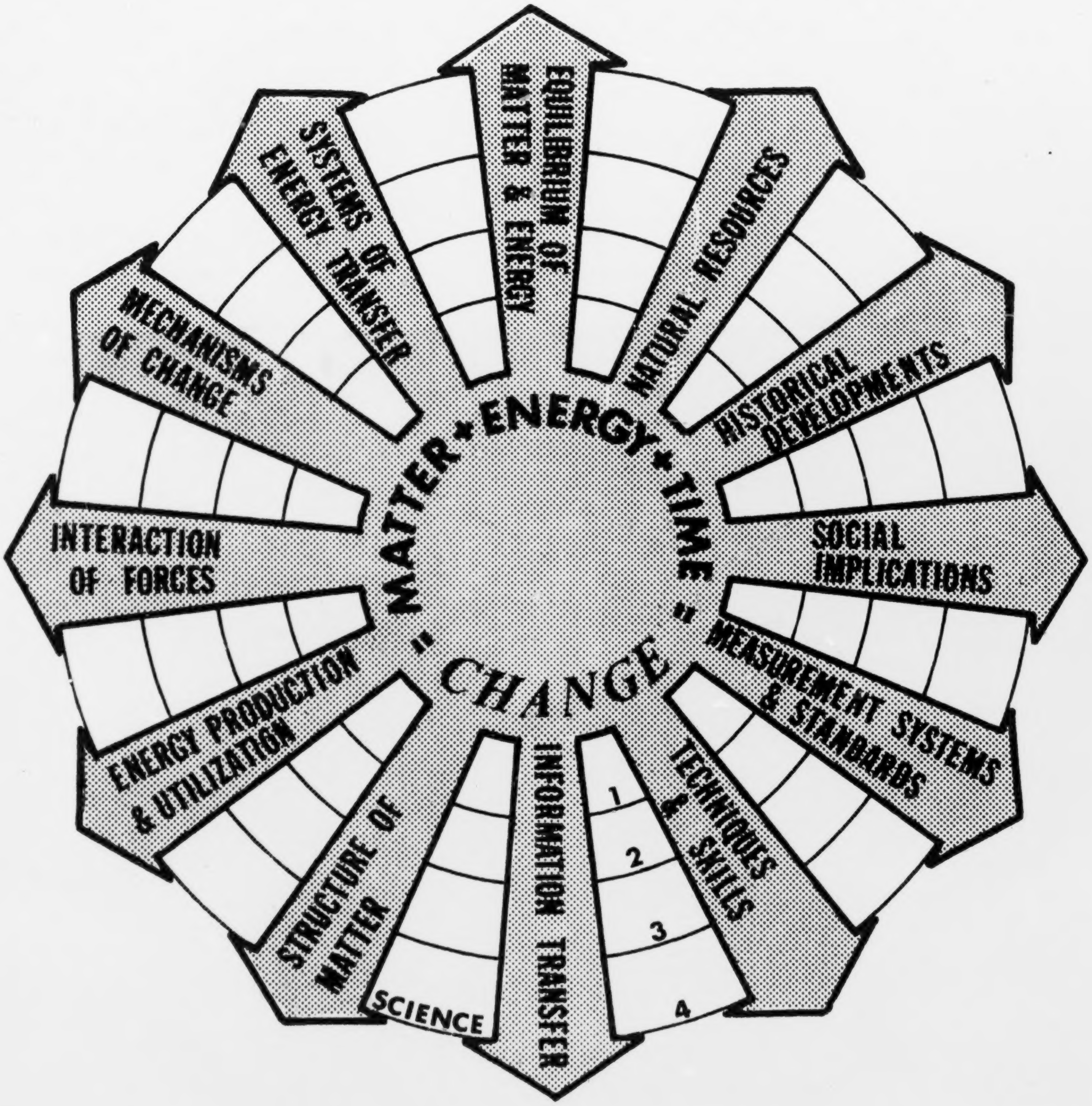
UNIFIED SCIENCE CURRICULUM
MONO[illegible] HIGH SCHOOL
MONONA, WISCONSIN 53716

SE 012 309

Part 1

UNIFYING THEMES

MONONA GROVE UNIFIED SCIENCE PROGRAM


EQUILIBRIUM OF MATTER & ENERGY
NATURAL RESOURCES
HISTORICAL DEVELOPMENTS
SOCIAL IMPLICATIONS
MEASUREMENT SYSTEMS & STANDARDS
TECHNIQUES & SKILLS
INFORMATION TRANSFER
STRUCTURE OF MATTER
ENERGY PRODUCTION & UTILIZATION
INTERACTION OF FORCES
MECHANISMS OF CHANGE
SYSTEMS OF ENERGY TRANSFER
" MATTER • ENERGY • TIME "
CHANGE
1
2
3
4
SCIENCE

INTRODUCTION

I. Class Procedures and Regulations

A. Grouping

1. Large Groups (50-55 Students) Rooms -- 67, 61
2. Laboratory Groups (24 Students) Rooms -- 61, 73, and 69
3. Small Groups (15-18 Students) Rooms -- 61, 73, 69, 67, 65 and other available rooms

When groups move from one room to another during a class session, the movement is expected to be accomplished quickly and quietly.

B. Personal Responsibility in the Classroom

1. When the bell signaling the beginning of a class session sounds, students are expected to come to order without further direction. Students not in their assigned seats at this time are considered to be tardy.
2. Students reporting to class late must present an "admit to class" pass.
3. The class will be dismissed by the teacher, not the bell, at the end of the class session.
4. Students detained by the teacher after the bell should obtain an admit to class pass before leaving the room.
5. Before leaving the classroom!
    a. Check your desk including the shelf and floor area to be sure that they are cleared of debris and in order.
    b. Place your chair under the desk.
6. The science department office located between rooms 61 and 65, is not to be used as a passage way by students.

C. Note Taking

1. The student notebook provides a basic outline of the course content.
2. Regular, careful, note taking in large group sessions is required in order to make the student notebook a useful reference for study.
3. An audio tape on effective note taking is available in the Resource Center.
4. Notebooks will be collected periodically to evaluate the quality of note taking.

D. Assignments

1. Assignment schedules will be given periodically. These schedules should be used to help budget time for homework and study for quiz sessions and hour examinations.

2. Types of homework assignments

   a. Reference reading:

      (1) Reading assignments will be made from selected references located in the Resource Center.

      (2) Generally the required reading assignments will also be available on audio tape.

      (3) "Check tests", one or two questions, will frequently follow a reading assignment.

   b. Problems, exercises and discussion questions:

      Duplicate copies of all problem assignments, exercises and discussion questions appear in the notebook. Carbon copies are handed in for evaluation.

   c. Laboratory reports - to be completed on special laboratory report forms.

3. Regulations pertaining to homework assignments

   a. On days when assignment is due at the beginning of the class session homework will be collected when the bell rings.

      (1) Problems, exercises or discussion questions missing after the collection of homework will be recorded as an F and be reflected in the Individual Performance Grade.

      (2) When excused absence is a factor the F may be converted to full credit provided that the assignment is completed within a specified period.

      (3) Laboratory reports missing at the time of collection will be graded F in Knowledge and Skills and affect the Individual Performance Grade.

      (4) If excused absence is not a factor, late laboratory reports may be submitted for a maximum of ½ credit in Knowledge and Skills.

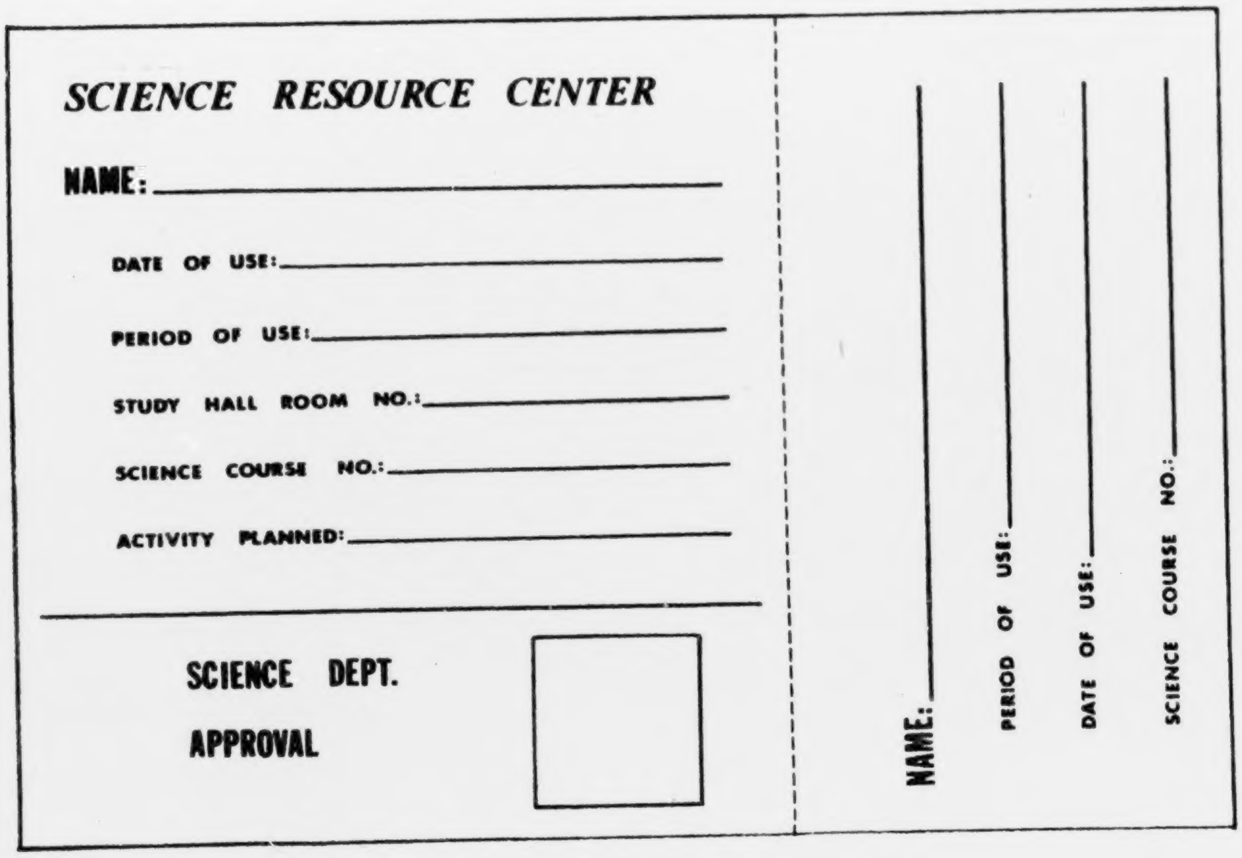
   b. Students absent from class are responsible for arrangements to complete assignments missed.

      (1) Assignments not handed in the day after returning to class will be graded as F, except in cases where requests for an extension of time have been approved.

      (2) Arrangements for making up a scheduled quiz or an hour examination must be completed the day the student returns to class. Any quiz or hour exam not made up will be averaged as F in the Knowledge and Skills Grade.

II. Science Resource Center

A. Use of the Resource Center Facilities



SCIENCE RESOURCE CENTER

NAME: ______________________

DATE OF USE: ______________________

PERIOD OF USE: ______________________

STUDY HALL ROOM NO.: ______________________

SCIENCE COURSE NO.: ______________________

ACTIVITY PLANNED: ______________________

SCIENCE DEPT. APPROVAL ☐

NAME: ______________________

PERIOD OF USE: ______________________

DATE OF USE: ______________________

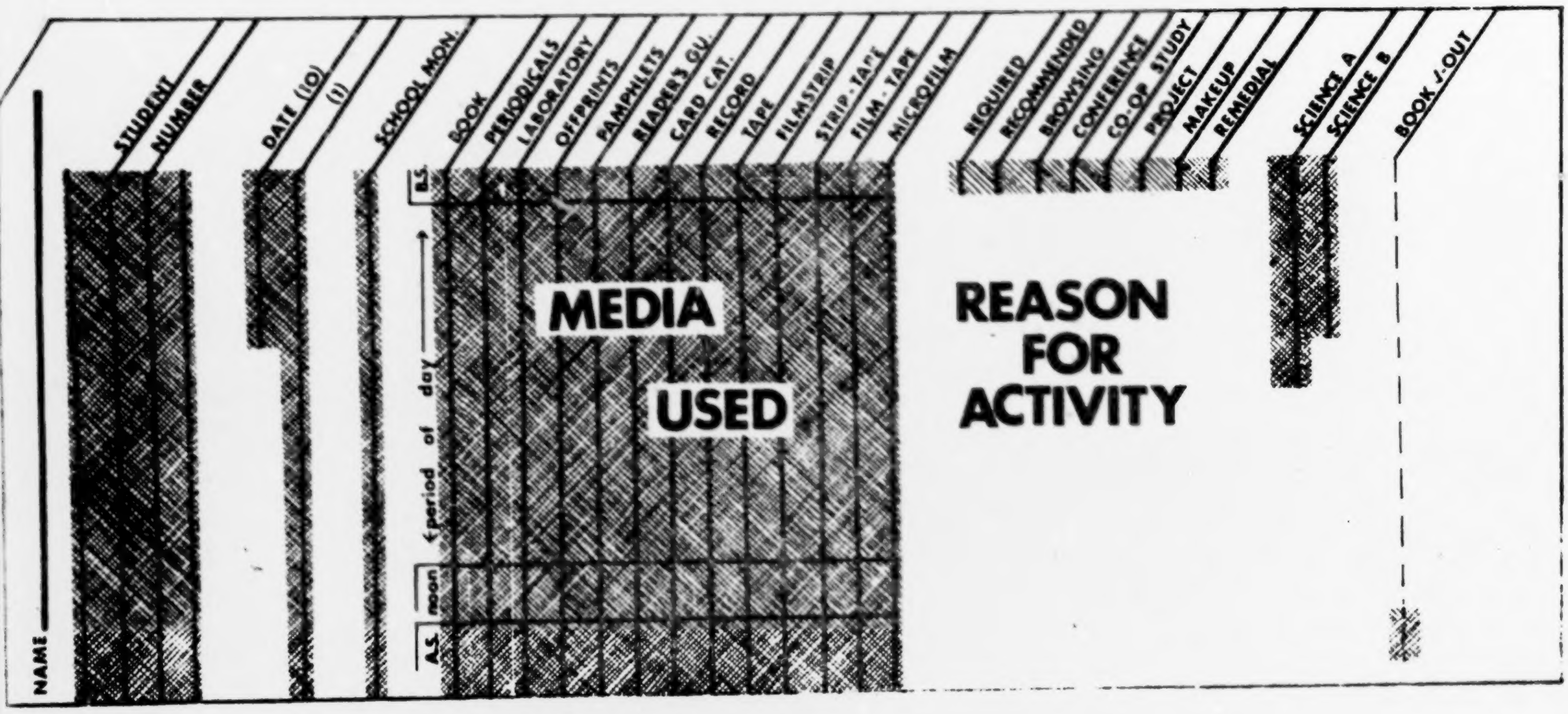
SCIENCE COURSE NO.: ______________________

1. The Resource Center may be used during any regularly scheduled study hall period by the "pass" system.
2. The Resource Center will be open from 12:15 to 12:45 every Tuesday, Wednesday, and Thursday noon.
3. Students wishing to use the Resource Center Facilities before or after school may do so by appointment.
4. Students must demonstrate the degree of self discipline necessary for effective independent or cooperative study in the Resource Center.

B. Circulation of Resource Center Reference Materials

1. No materials will be checked out during the school day.
2. Books, magazines, offprints, and special materials may be checked out on an "overnight" basis only. Check out period is from 3:45 to 4:00 p.m. daily.
3. All materials must be returned by 8:00 a.m. the next day.
4. Failure to comply with any of the above procedures will be reflected in the Citizenship Grade.

C. Use of the Porta-Punch Card


NAME
STUDENT
NUMBER
DATE (10)
(1)
SCHOOL MON.
BOOK
PERIODICALS
LABORATORY
OFFPRINTS
PAMPHLETS
READER'S GU.
CARD CAT.
RECORD
TAPE
FILMSTRIP
STRIP-TAPE
FILM-TAPE
MICROFILM
REQUIRED
RECOMMENDED
BROWSING
CONFERENCE
CO-OP STUDY
PROJECT
MAKEUP
REMEDIAL
SCIENCE A
SCIENCE B
BOOK ✓-OUT
B.S.
period of day
noon
A.S.
MEDIA USED
REASON FOR ACTIVITY

1. Print your name on the card.
2. Punch out the correct information on the shaded (red) area.

D. Guide to Student Use of the Science Resource Center

1. The Science Resource Center is designed and equipped to provide an opportunity for students to do independent or cooperative study in the area of science.
2. Students who come to the Resource Center must have a specific purpose which requires the use of the facilities in the Center!
3. Students who use the Resource Center Facilities must record the nature of their activity in the Center by use of the Porta-Punch Card.
4. All cooperative study between two students must be done at the conference tables. Students sitting at the study carrels are expected to work individually without any conversation with other students.
5. All students are encouraged to take advantage of the opportunities that the Resource Center provides for individual help with any problems or difficulties experienced in their science course.
6. The use of the Resource Center Facilities requires self discipline on the part of the student in order to develop effective individual study skills. Students who are unable to exercise the self discipline required to maintain an atmosphere conducive to independent study will not be permitted to use the Resource Center Facilities until such time that they can demonstrate this ability.
7. Maintenance Responsibilities
   a. Turn volume off when headsets are not in use.
   b. Leave all reference books on the carrel shelf in good order. All cataloged books and periodicals are to be returned to the proper space in the drawers or shelves.
   c. Keep desk storage area free of debris and desk surfaces clean.

III. Grades and grading

A. Basis for the evaluation of Individual Performance and School Citizenship:

*See accompanying sheets or student handbook for points considered in grading these categories. Individual Performance and School Citizenship will be evaluated three times each quarter.

B. Basis for the evaluation of student progress in the area of Knowledge and Skills:

1. The grade point system

4.0 3.9 3.8	4.3 A+
3.7 3.6 3.5	4.0 A
3.4 3.3 3.2	3.7 A-
3.1 3.0	3.3 B+
2.9 2.8 2.7	3.0 B
2.6 2.5	2.7 B-
2.4 2.3 2.2	2.3 C+
2.1 2.0 1.9	2.0 C
1.8 1.7 1.6	1.7 C-
1.5 1.4	1.3 D+
1.3 1.2 1.1	1.0 D
1.0 .9	.7 D-
.8 .7 .6 .5	.3 F+
.4 .3 .1 .0	.0 F

2. Determination of grade point

Daily Work - ½ of Knowledge and Skills Grade

Quizzes a. short 5 minute unannounced test covering material presented in large group sessions or homework assignments

b. 15-30 minute announced test

Written laboratory problem and investigation reports

Hour Examinations - ½ of Knowledge and Skills Grade

Daily work and hour examinations not completed will be averaged as zero.

C. Final Total Growth Grade

1. Each of the four, quarterly, total growth grades plus the Final Evaluation are averaged equally to give the final Total Growth Grade in the course.

2. Final Evaluation

a. The final written examination in the course will count as one-half of the Final Evaluation.

b. A final appraisal of Individual Performance and School Citizenship will determine the remaining half of the Final Evaluation Grade.

FACTORS DEFINING INDIVIDUAL PERFORMANCE

Works up to ability

1. Does work which compares favorably with ability as measured by test scores.
2. Does daily work which compares favorably with best work done in a grading period.
3. Tries to make the best use of his particular talents and opportunities.
4. Carefully completes each day's assignment.
5. Reworks and corrects errors in assignments after class checking.
6. Goes beyond regular assignments to learn more about the subject.
7. Spends time reviewing.
8. Shows improvement rather than staying at one point.

Has a positive attitude

1. Has a sincere desire and interest in learning.
2. Is willing to try - is willing to be exposed to new information and ideas.
3. Has respect for the opinions of others.
4. Accepts correction well and constantly tries to improve.
5. Takes pride in his work.
6. Responds as well to group instruction as to individual instruction.
7. Does not argue over trivial points.
8. Does not show negative feelings in class - straightens things out alone with teacher.
9. Is willing to accept special jobs.

Shows self-direction

1. Demonstrates ability to carry on independent or cooperative study using Resource Center materials.
2. Works for understanding rather than a grade.
3. Is self-starting and self-sustaining.
4. Does his own work - has confidence in it.
5. Tries assignments himself before seeking help.
6. Knows when and how to seek help.
7. Initiates makeup assignments and does them promptly.
8. Is resourceful- uses imagination.
9. Settles down to work immediately.
10. Shows initiative.

Plans work wisely

1. Completes assignments and turns them in on time.
2. Is prepared for class - brings all necessary materials.
3. Makes good use of study time.
4. Follows directions.
5. Anticipates needs in work projects.
6. Organizes time so there is no last minute rush job.
7. Moves quickly and quietly when given an assignment.

FACTORS DEFINING SCHOOL CITIZENSHIP

Is courteous and considerate of others

1. Is courteous to other students, to teachers or any person with whom he comes in contact, for example the custodial staff.
2. Is quiet and attentive in class discussion.
3. Listens carefully to student questions, answers and comments as well as to those of the teacher.
4. Uses only constructive criticism - avoids ridicule.
5. Is tolerant of errors made by others.
6. Receives recognition before speaking.
7. Is ready to begin work when the bell rings.
8. Accepts the "spirit" as well as the letter of school regulations.
9. Shows halllway conduct which is orderly and in good taste.
10. Shows good assembly conduct.
11. Is quiet and attentive during P.A. announcements.
12. Is quiet in hallways when school is in session.
13. Carries out classroom activity in a quiet and businesslike manner.

Is responsible

1. Demonstrates self discipline necessary for effective use of Resource Center Facilities.
2. Keeps appointments.
3. Carries out assigned tasks.
4. Can be left unsupervised for a period of time.
5. Gets to class on time.
6. Meets obligations, fees, etc.
7. Returns borrowed items.
8. Has a good attendance record.
9. Keeps name off library list.
10. Presents excuse for absence.
11. Returns report card on time.

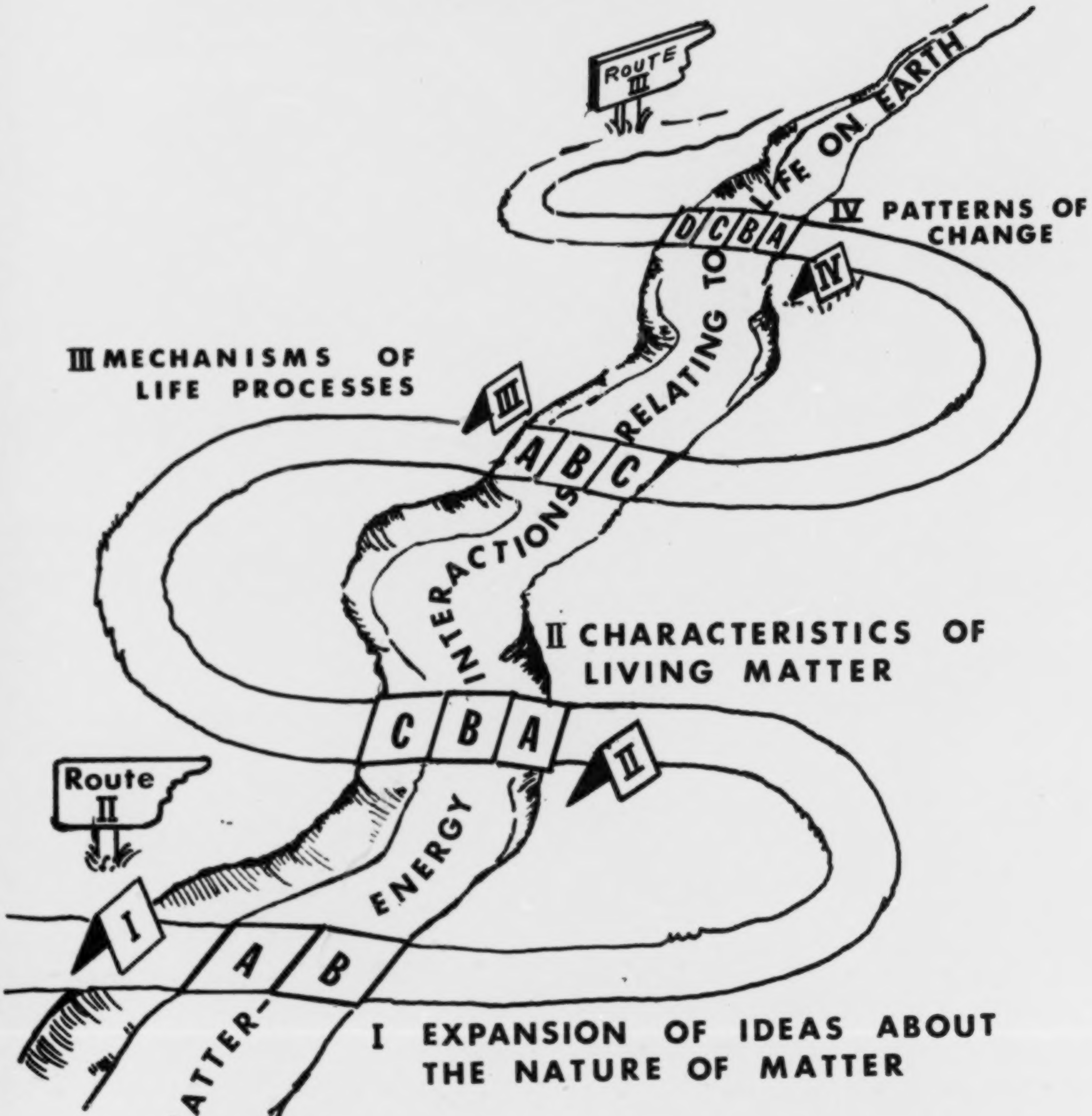
Contributes his share

1. Works to develop and uphold the good reputation of the school.
2. Participates in class discussion in a constructive manner - asks questions as well as volunteering information - shares ideas.
3. Participates in at least one school activity as a cooperative, contributing member.
4. Accepts jobs such as taking part in panels, putting up bulletin boards, helping direct class activities, getting information.
5. Brings examples, clippings, supplementary materials to class.
6. Contributes to success of class in a physical way - straightens chairs, pulls blinds, etc.

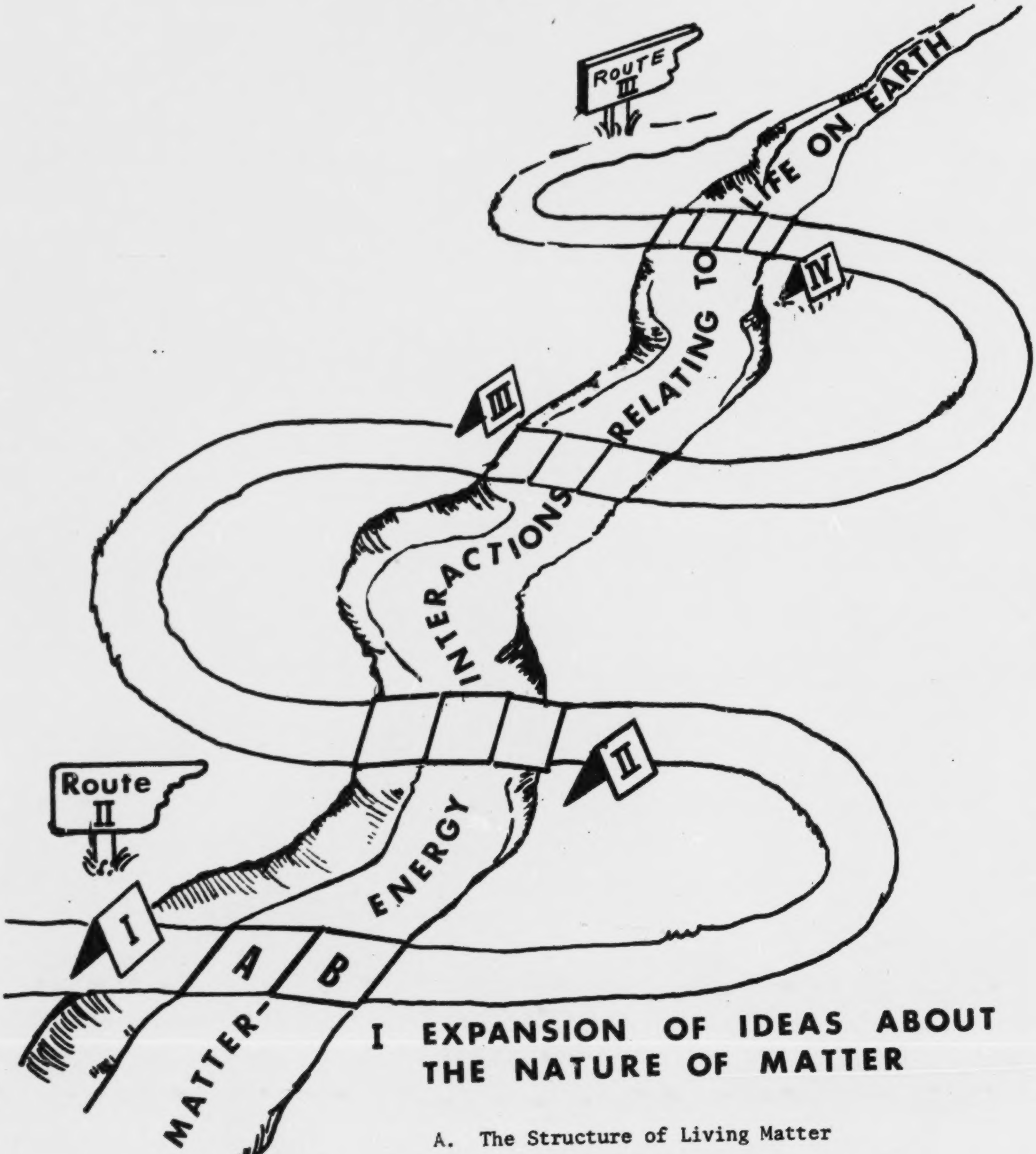
Is a good leader or follower

1. Cooperates willingly with the majority even though his point of view is with the minority.
2. Works constructively to change practices he is not in agreement with.
3. Works willingly with any group, not just his particular friends.
4. Helps class move along positively.
5. Leads in class discussion.
6. Responds to suggestions.

SCIENCE IIA


ROUTE III
MATTER-ENERGY INTERACTIONS RELATING TO LIFE ON EARTH
D C B A
IV PATTERNS OF CHANGE
IV
III MECHANISMS OF LIFE PROCESSES
III
A B C
II CHARACTERISTICS OF LIVING MATTER
C B A
II
Route II
I
A B
I EXPANSION OF IDEAS ABOUT THE NATURE OF MATTER

SCIENCE IIA


Route III
Route II
I
II
III
IV
A
B
MATTER-ENERGY
INTERACTIONS
RELATING TO
LIFE ON EARTH

I EXPANSION OF IDEAS ABOUT THE NATURE OF MATTER

A. The Structure of Living Matter

B. Particle Kinetics in Fluid Systems

The Structure of Living Matter

EXTENSIONS OF ATOMIC THEORY

Required Reading: Modern Chemistry, p. 222-223

Recommended Reading: The World of Carbon, (547 AS) Isaac Asimov

INTRODUCTION:

Although there are 92 different kinds of elements which make up the composition of our planet, four of these elements, Hydrogen, Oxygen, Nitrogen and Carbon account for slightly more than 97% of the weight of all living matter. Of these four elements carbon is the most unique and significant in the structure of living matter. Because the carbon atom has four electrons in its outermost orbit it forms compounds with other elements by a process different from that of electron transfer. Sodium, which has only one electron in its outer orbit, transfers its external valence electron to an acceptor and thereby acquires a positive electrical charge. Acceptor atoms which have more than four but less than eight electrons in their outer orbit tend to gain electrons and thus acquire the chemical stability of an inert gas but in the process they acquire a negative electrical charge. The positive and negative ions formed as a result of the transfer of electrons from one atom to another come together in response to the force at attraction between unlike charges to form ionic compounds.

Carbon, with four valence electrons, has no more tendency to lose than to gain electrons and tends to resist acquisition of either a positive or negative charge. Elements like carbon, which have four valence electrons are chemically unstable and subsequently do combine with other atoms to acquire a stable electron octet. However, these atoms attain this stability by sharing electrons and form compounds as a result of covalent bonds. This type of bonding is characteristic of the chemical compounds found in all living matter. Every molecule of living matter contains atoms of carbon covalently bonded to other atoms.

Two questions relative to the nature of living matter may kindle one's curiosity:

First. Since there are obviously other elements than carbon which have four electrons in their outer-most orbit, elements like silicon, lead, and germainium, how does it happen that all molecules of living matter are composed of carbon atoms covalently bonded to other atoms?

Second. At the present time more than 1,700,000 different carbon compounds are already known and more are being discovered in living matter or formed in laboratories each day. The number of known chemical compounds composed of all the elements, other than carbon, comes to about 500,000. How can this be? How is it possible for one element to form so many different kinds of compounds?

The answers to these two questions is to be found in the uniqueness of the carbon atom. In this portion of our inquiry about the nature of matter we shall try to discover more about the special properties of carbon so that we will in turn be able to understand more about ourselves.

The Structure of Living Matter

EXTENSIONS OF ATOMIC THEORY

I. Classification of Elements in the Basis of Chemical Properties

   A. Metals

   B. Non-metals

   C. Metalloids

II. The Chemical Activity of the Elements

   A. Electro-positivity

   B. Electro-negativity

PERIODIC TABLE OF ELECTRONEGATIVITIES

2.1 H 1																	He 2
1.0 Li 3	1.5 Be 4											2.0 B 5	2.5 C 6	3.0 N 7	3.5 O 8	4.0 F 9	Ne 10
0.9 Na 11	1.2 Mg 12											1.5 Al 13	1.8 Si 14	2.1 P 15	2.5 S 16	3.0 Cl 17	Ar 18
0.8 K 19	1.0 Ca 20	1.3 Sc 21	1.5 Ti 22	1.6 V 23	1.6 Cr 24	1.5 Mn 25	1.8 Fe 26	1.8 Co 27	1.8 Ni 28	1.9 Cu 29	1.6 Zn 30	1.6 Ga 31	1.8 Ge 32	2.0 As 33	2.4 Se 34	2.8 Br 35	Kr 36
0.8 Rb 37	1.0 Sr 38	1.2 Y 39	1.4 Zr 40	1.6 Nb 41	1.8 Mo 42	1.9 Tc 43	2.2 Ru 44	2.2 Rh 45	2.2 Pd 46	1.9 Ag 47	1.7 Cd 48	1.7 In 49	1.8 Sn 50	1.9 Sb 51	2.1 Te 52	2.5 I 53	Xe 54
0.7 Cs 55	0.9 Ba 56	1.2 Lu 71	1.3 Hf 72	1.5 Ta 73	1.7 W 74	1.9 Re 75	2.2 Os 76	2.2 Ir 77	2.2 Pt 78	2.4 Au 79	1.9 Hg 80	1.8 Tl 81	1.8 Pb 82	1.9 Bi 83	2.0 Po 84	2.2 At 85	Rn 86
0.7 Fr 87	0.9 Ra 88																

1.1 La 57	1.1 Ce 58	1.1 Pr 59	1.1 Nd 60	1.1 Pm 61	1.1 Sm 62	1.1 Eu 63	1.1 Gd 64	1.1 Tb 65	1.1 Dy 66	1.1 Ho 67	1.1 Er 68	1.1 Tm 69	1.1 Yb 70
1.1 Ac 89	1.3 Th 90	1.5 Pa 91	1.7 U 92	1.3 Np 93	1.3 Pu 94	1.3 Am 95	1.3 Cm 96	1.3 Bk 97	1.3 Cf 98	1.3 Es 99	1.3 Fm 100	1.3 Md 101	1.3 102

Periodic Table showing the electronegativities of the elements on an arbitrary scale.

III. Factors Which Affect the Activity of Atoms

A. Number of Protons

B. Atomic Diameter

C. "Specific Effects"

IV. The Formation of Chemical Compounds with Covalent Bonds

A. Types of Atoms which form Covalent Bonds

B. Types of Covalent Bonds

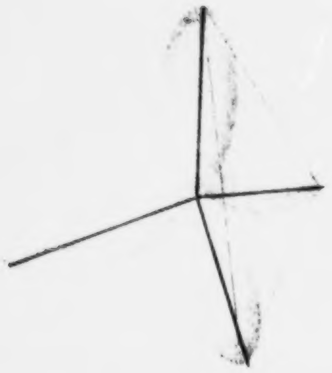
V. The Uniqueness of the Carbon Atom

A. Occurrence of carbon in nature

1. Diversity of carbon compounds

2. Relationship to living matter

B. The Structure of the Carbon Atom



The four covalent bonds of a carbon atom are directed in space toward the four vertices of a regular tetrahedron if the center of the atom is at the center of the tetrahedron.

C. Factors Which Make Carbon Unique in Forming Chemical Bonds

1. Number of electrons

2. Electron orientation

3. Atomic diameter

THE ATOMIC DIAMETERS OF THE ELEMENTS IN RELATION TO THEIR POSITIONS IN THE PERIODIC TABLE

* Atomic number
Symbol
Atomic diameter Å

Transition elements

Period	Character	Light metals		Heavy metals										Non-metals					
	Orbitals	s		d										p (except He)					
	Group	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
1	*	1 H																	2 He
2	*	3 Li 2.45	4 Be 1.78											5 B 1.60	6 C 1.54	7 N 1.48	8 O 1.48	9 F 1.44	10 Ne
3	*	11 Na 3.14	12 Mg 2.73											13 Al 2.50	14 Si 2.35	15 P 2.20	16 S 2.08	17 Cl 1.99	18 Ar
4	*	19 K 4.05	20 Ca 3.47	21 Sc 2.88	22 Ti 2.65	23 V 2.45	24 Cr 2.34	25 Mn 2.34	26 Fe 2.33	27 Co 2.31	28 Ni 2.30	29 Cu 2.35	30 Zn 2.50	31 Ga 2.49	32 Ge 2.45	33 As 2.42	34 Se 2.34	35 Br 2.28	36 Kr
5	*	37 Rb 4.32	38 Sr 3.83	39 Y 3.23	40 Zr 2.91	41 Nb 2.68	42 Mo 2.58	43 Tc	44 Ru 2.48	45 Rh 2.49	46 Pd 2.56	47 Ag 2.68	48 Cd 2.83	49 In 3.00	50 Sn 2.82	51 Sb 2.82	52 Te 2.74	53 I 2.67	54 Xe
6	*	55 Cs 4.70	56 Ba 3.96	57 La 3.38	72 Hf 2.88	73 Ta 2.69	74 W 2.60	75 Re 2.56	76 Os 2.51	77 Ir 2.52	78 Pt 2.58	79 Au 2.67	80 Hg 2.88	81 Tl 3.10	82 Pb 3.08	83 Bi 3.04	84 Po 3.06	85 At	86 Rn
7	*	87 Fr	88 Ra	89 Ac															

	f orbitals													
Lanthanides Group IIIB	58 Ce 3.29	59 Pr 3.30	60 Nd 3.28	61 Pm	62 Sm 3.32	63 Eu 3.70	64 Gd 3.23	65 Tb 3.18	66 Dy 3.18	67 Ho 3.16	68 Er 3.13	69 Tm 3.12	70 Yb 3.40	71 Lu 3.11
Actinides	90 Th 3.30	91 Pa	92 U 2.84	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 E	100 Fm	101 Mv		

D. Special Properties of Carbon

1. Physical

THE GROUP IVA ELEMENTS

Element	Period	At. no.	At. wt	At. diam.	Configuration	Density	Mp	Bp	Color and state	Electric cond	Oxidation states	Character of oxide
Carbon	2	6	12.01	1.54	2, 4	2.25	sublimes 3500°	—	silver-gray, brittle, solid	good	−4, 2, 4	acidic
Silicon	3	14	28.06	2.35	2, 8, 4	2.40	1430°	2600°	silver-gray, brittle, solid	poor	−4, 2, 4	acidic
Germanium	4	32	72.60	2.45	2, 8, 18, 4	5.36	960°	2700°	gray, brittle, crystalline, metallic	fair	2, 4	amphoteric
Tin	5	50	118.70	2.82	2, 8, 18, 18, 4	7.31	232°	2260°	silver-gray, metal	good	2, 4	amphoteric
Lead	6	82	207.21	3.08	2, 8, 18, 32, 18, 4	11.34	327°	1744°	silver-gray, metal	good	2, 4	amphoteric

2. General Characteristics of Carbon Compounds found in Living Matter

a. types of compounds

b. chemical stability

3. Why carbon, alone, is uniquely suited to the formation of the chemical compounds which characterize living matter.

MOLECULAR STRUCTURES BASIC TO LIVING MATTER

Water

Required Reading:	Modern Chemistry, pages 148-153 Water, The Mirror of Science, Davis and Day, pages 17-36, 90-102, 138-142
Recommended Reading:	Water, The Mirror of Science, Davis and Day, pages 142-172 Water, Life Science Library, pages 8-15 and 16-30

INTRODUCTION:

The molecular structures found in living matter are quite complex - except for water. At first glance the water molecule is deceptively simple. It is made of only two elements, hydrogen and oxygen. These are combined in a simple ratio of two hydrogen atoms to one oxygen atom with covalent bonds which represent the simplest type of electron sharing possible in compounds. Moreover, the water molecule, only 3 Angstroms in diameter, is one of the smallest molecules known.

In spite of these unimpressive characteristics the water molecule plays a unique role in the life process. It is indeed a "wonder molecule", apparently custom designed for the tasks it accomplishes in the living environment. No other inorganic molecule even approaches the water molecule in the critical position it occupies for without it life, as we know it, could not have evolved nor could it continue to exist.

In this section we will take a comprehensive look at the water molecule, explore in detail its structure and study its functions relative to living matter.

MOLECULAR STRUCTURES BASIC TO LIVING MATTER

Water

QUESTIONS FOR CONSIDERATION

1. What role did the unusual physical properties of water play in the primitive earth?

2. Is the unequal sharing of electrons by hydrogen and oxygen or the 105° angle the more significant fact?

3. What would be the effect on the water molecule if the angle between the hydrogen atoms was 180° instead of 105°?

4. How would life be changed if the water molecule were not polar?

5. Is there water in space?

   In what form would it have to be?

   What is the "dust of space" made up of?

MOLECULAR STRUCTURES BASIC TO LIVING MATTER

Water

I. Structure of the Water Molecule

A. Position of the oxygen orbitals

B. Formation of the water molecule

1. Initial phases

2. Electronegativity and distribution of the charge

3. Formation of the 105° angle

4. The polar molecule (dipole) and the polar bond

C. The Hydrogen Bond

II. Unusual physical properties of water

A. Unusual boiling and freezing points

B. Capacity as a solvent and ionizer

C. High surface tension

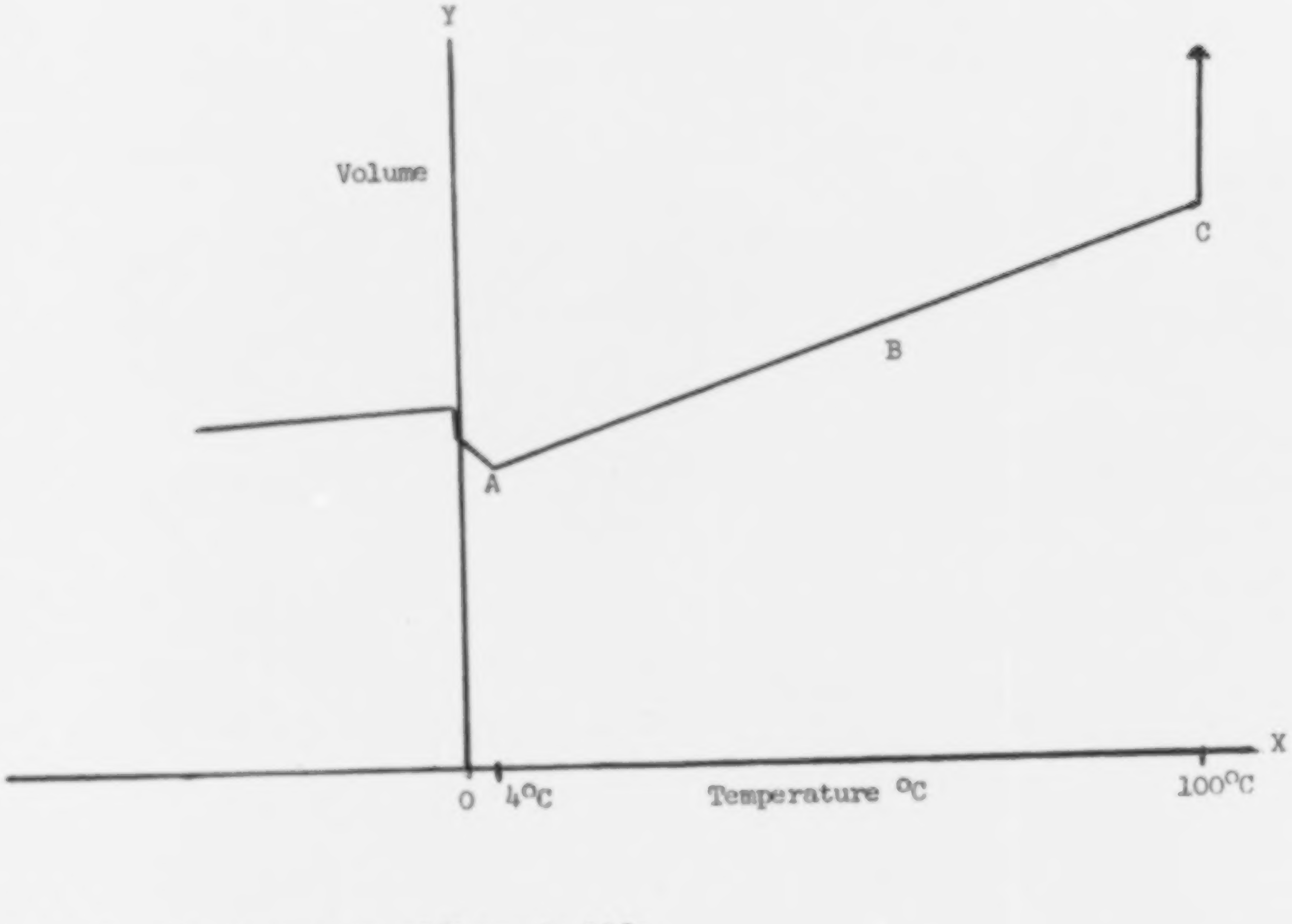
D. High tensile strength

E. High Specific Heat

F. High Adhesion

G. Density of the Solid State

III. Change of State Curve



IV. The Importance of Water in Life

Exercise

Name ____________________

Science IIA Hour _____

Date ____________________

WATER

1. Sketch the electron dot formula for water.

2. List four usual physical properties of water.

3. List seven unusual physical properties of water.

4. What is the underlying cause of these seven unusual properties?

5. What causes the unequal electron distribution (unequal sharing) in the water molecule?

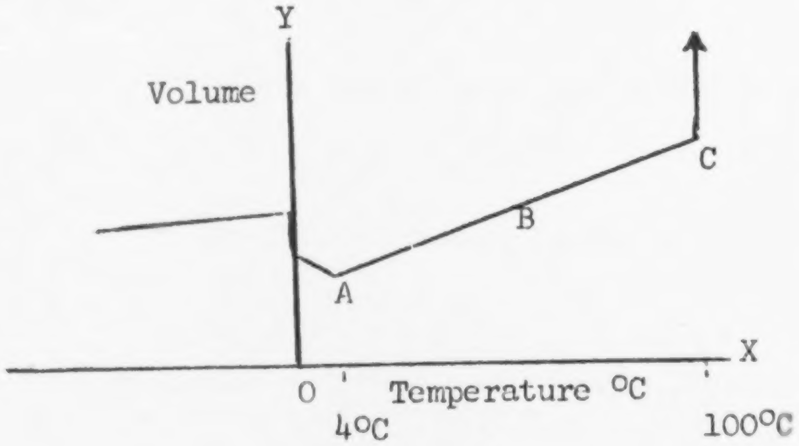
6. What basic fact is responsible for the appearance of the electric charge in two distinct areas of the molecule?

7. Why is the angle 105° rather than 90°?

8. Distinguish between a covalent bond and the hydrogen bond.

9. According to the molecular theory molecules are, in general, closer in a solid than in a liquid, thus making densities of the solid state of a substance greater than in the liquid state. Why is then ice less dense than water?

10. The graph below represents the change of volume of water and ice with changes in temperature.



a. What is the significance of Point A?

b. What state of matter exists to the left of the Y axis?

c. What state of matter exists above 100°C?

d. If one gram of water is considered, what volume will it occupy at 4°C?

e. What volume will one gram of water occupy at 100°C?

f. If ice has a density of .9 g/cc, what volume will one gram of water occupy after it is changed to ice at 0°C?

g. Starting at the left discuss in terms of the hydrogen bond the changes which occur as heat is applied to ice to change it to water and then to steam.

h. Give the probable formula for water at Point A.

i. Give the probable formula for water at Point B.

j. Give the probable formula for water at Point C.

MOLECULAR STRUCTURES BASIC TO LIVING MATTER

Organic Molecules

Required Readings:

BSCS Yellow Version, pp 91-99; The Principle Compounds of Cells.

BSCS Green Version, pp 394-401; Syntheses

BSCS Blue Version, pp 153-159; The Language of Life

I. Organic Molecules - a definition

II. Kinds of Organic Molecules Basic to Living Matter

A. Carbohydrates

1. Characteristics

2. Classification

3. Functions

MOLECULAR STRUCTURES BASIC TO LIVING MATTER, Continued

B. Proteins

1. Characteristics

2. Classification

3. Functions

C. Fats

1. Characteristics

2. Classification

3. Functions

D. Nucleic Acids

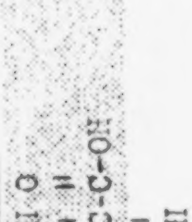
1. Characteristics

2. Classification

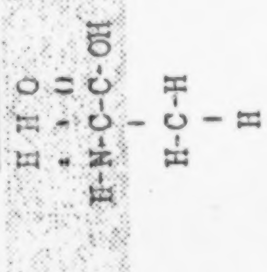
3. Functions

THE AMINO ACIDS

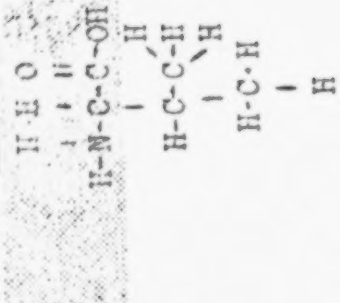
GLYCINE



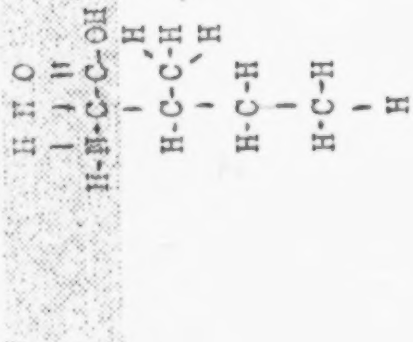
ALANINE



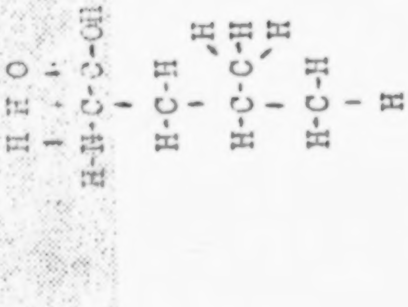
VALINE



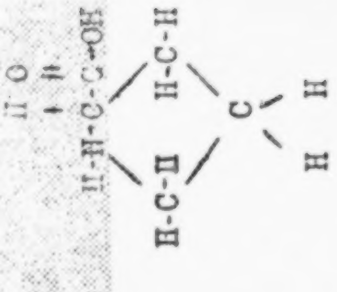
ISOLEUCINE



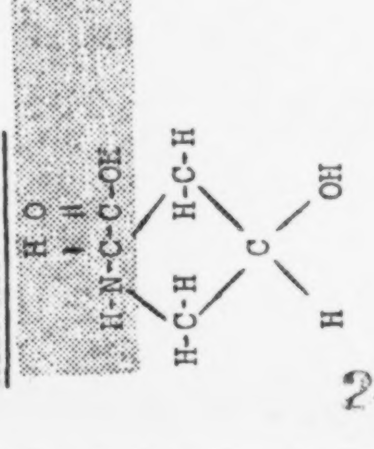
LEUCINE



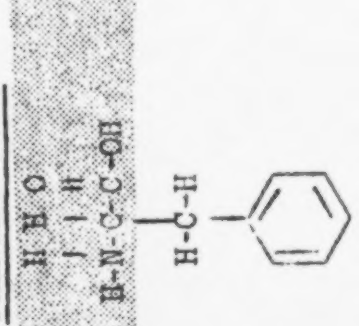
PROLINE



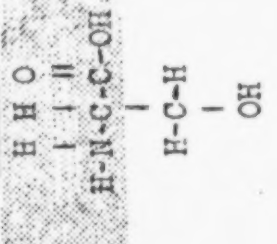
HYDROXYPROLINE



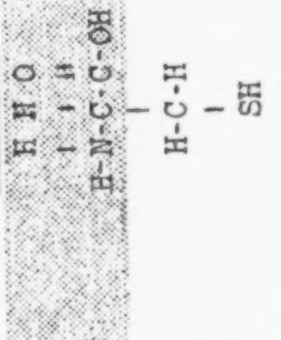
PHENYLALANINE



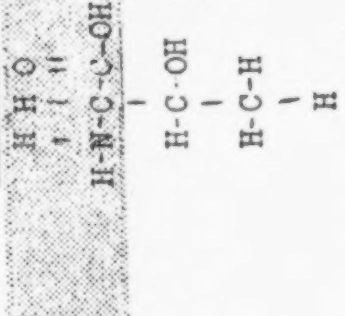
SERINE



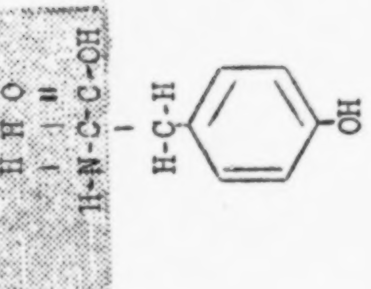
CYSTEINE



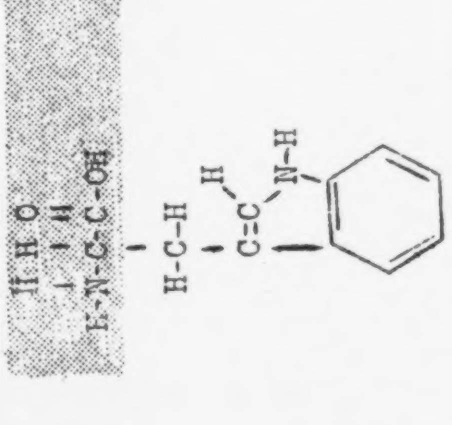
THREONINE



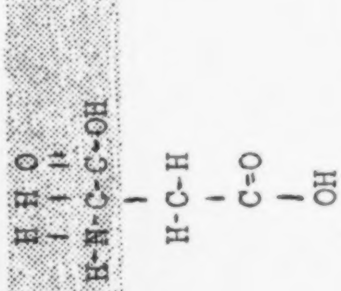
TYROSINE



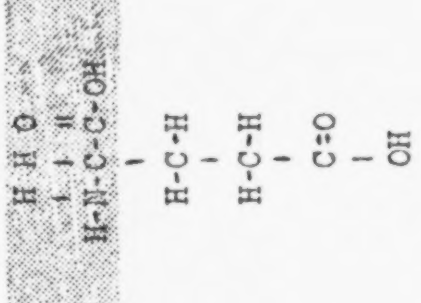
TRYPTOPHAN



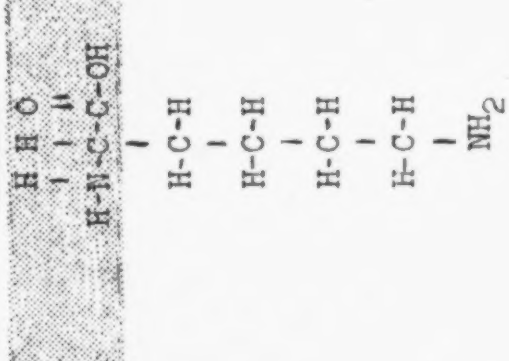
ASPARTIC ACID



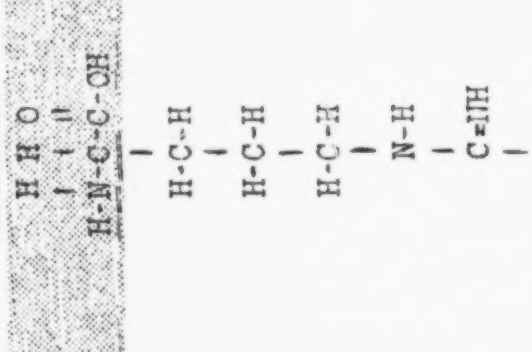
GLUTAMIC ACID



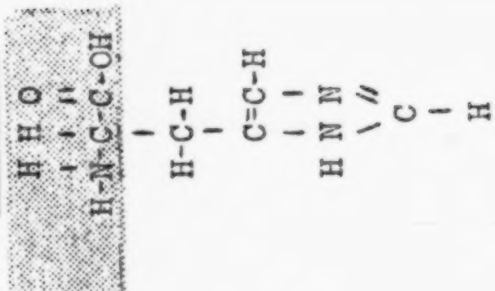
LYSINE



ARGININE



HISTIDINE



Laboratory Exercise

Characteristics and Identification of Carbohydrates

Part I.

PURPOSE: The purpose of this exercise is to become familiar with chemical means of identifying various types of carbohydrates. Specifically, we will be working with the following carbohydrates.

Monosaccharides -	d-fructose
	d-glucose
Disaccharides -	lactose
Polysaccharides -	starch
	cellulose

INTRODUCTORY NOTES:

All living organisms require a constant supply of energy in order to maintain the level of structural organization which permits the whole unit to function as a living organism. The ultimate source of energy for all life on this planet is the sun. It's energy is stored chemically in carbohydrates which the plants of the earth synthesize out of CO_2 and H_2O.

There are thousands of different kinds of carbohydrates but all of them may be generally classified as being some kind of monosaccharide, or disaccharide or polysaccharide. Large polysaccharide molecules are formed from the chemical union of many monosaccharide units. The formation of polysaccharides like cellulose and starch permits organisms to store energy more efficiently - because of the polysaccharide's larger number of chemical bonds - than in mono or disaccharides.

PROCEDURE:

A. MONOSACCHARIDE IDENTIFICATION

1. Benedict's Test - A general test for any monosaccharide.

   Place 1-2 ml of the solution to be tested in a test tube. Add 6 drops of Benedict's Solution. Place test tube in boiling water bath for 5 minutes. Note results on p.21

2. Barfoed's Test - A general test for any monosaccharide.

   To 1-2 ml of the solution to be tested add an equal amount of Barfoed's Solution. Place test tube in boiling water bath for 5 minutes. Note results.

3. Seliwanoff's Test - A specific test for the monosaccharide fructose.

   Add 5 ml of Seliwanoff's Reagent to a test tube. Add a few drops of the solution to be tested. Heat to boiling CAREFULLY over the Bunsen burner. Boil 20 seconds. Note results.

4. Molisch Test - A specific test for the monosaccharide glucose.

   To 5 ml of the solution to be tested add 2 drops of Molisch Reagent. Mix thoroughly, then incline the tube and allow about 3 cc concentrated sulfuric acid (CARE!) to flow down the side of the tube thus forming a layer of acid beneath the sugar.

B. DISACCHARIDE IDENTIFICATION

Disaccharides can be hydrolyzed to monosaccharides, or simple sugars, by the action of hydrochloric acid and heat.

Place 2 ml. of disaccharide solution in a test tube. Test with Benedict's solution. Note results.

Again place 2 ml of sucrose in a clean test tube. This time add 3 drops dilute HCl. Boil gently for one minute. Add NaOH solution dropwise until the solution is just basic. (Test with litmus.) Again test with Benedict's solution. Note results.

C. POLYSACCHARIDE IDENTIFICATION

1. Starch - Place 5 ml. starch solution to be tested in a test tube. Add 6 drops iodine (Lugol's) solution. Centrifuge 7-8 minutes. Note results.

   Pour off the liquid (supernatant) into a second test tube. Add 6 drops iodine solution. Note results.

2. Cellulose - Place cellulose to be tested in a test tube. Add 6 drops Benedict's solution. Heat in water bath 5 minutes. Note results.

   Again place cellulose to be tested in a clean test tube, add 2-3 ml. Cross and Bevan's Reagent and stir. Then add 2 ml. 95% ethyl alcohol. Note results.

Name ______________________________

Science IIA Hour ____

Date Due ____________________________

CONCLUSION:

Name the test required to identify the carbohydrates listed. Describe the results of a positive test.

Carbohydrate Tested	Test Reagents Required*	Confirming Results
1. Any monosaccharide		
2. d-Fructose		
3. d-Glucose		
4. Sucrose		
5. Starch		
6. Cellulose		

* Avoid details of procedures. State only the test reagent required and the result which confirms the test.

Laboratory Exercise

CHARACTERISTICS AND IDENTIFICATION OF CARBOHYDRATES

Identification of Unknown Carbohydrates

Part II.

INTRODUCTION:

1. Monosaccharides reacts with Benedict's and also Barfoed's reagent to yield an orange-red suspension which may be removed by centrifuging.

2. Fructose solution reacts with Seliwanoff's Reagent (resorcinol and 25% HCl) to yield a pink-red solution.

3. Glucose reacts with Molisch reagent and H_2SO_4 to form a purple violet zone.

4. A sucrose solution made acidic with HCl reacts with Barfoed's solution to yield a reddish colored precipitate. HCl hydrolizes sucrose and Barfoed's them reacts with the simple sugars.

5. Iodine solution reacts with starch to give a blue-black colored solution.

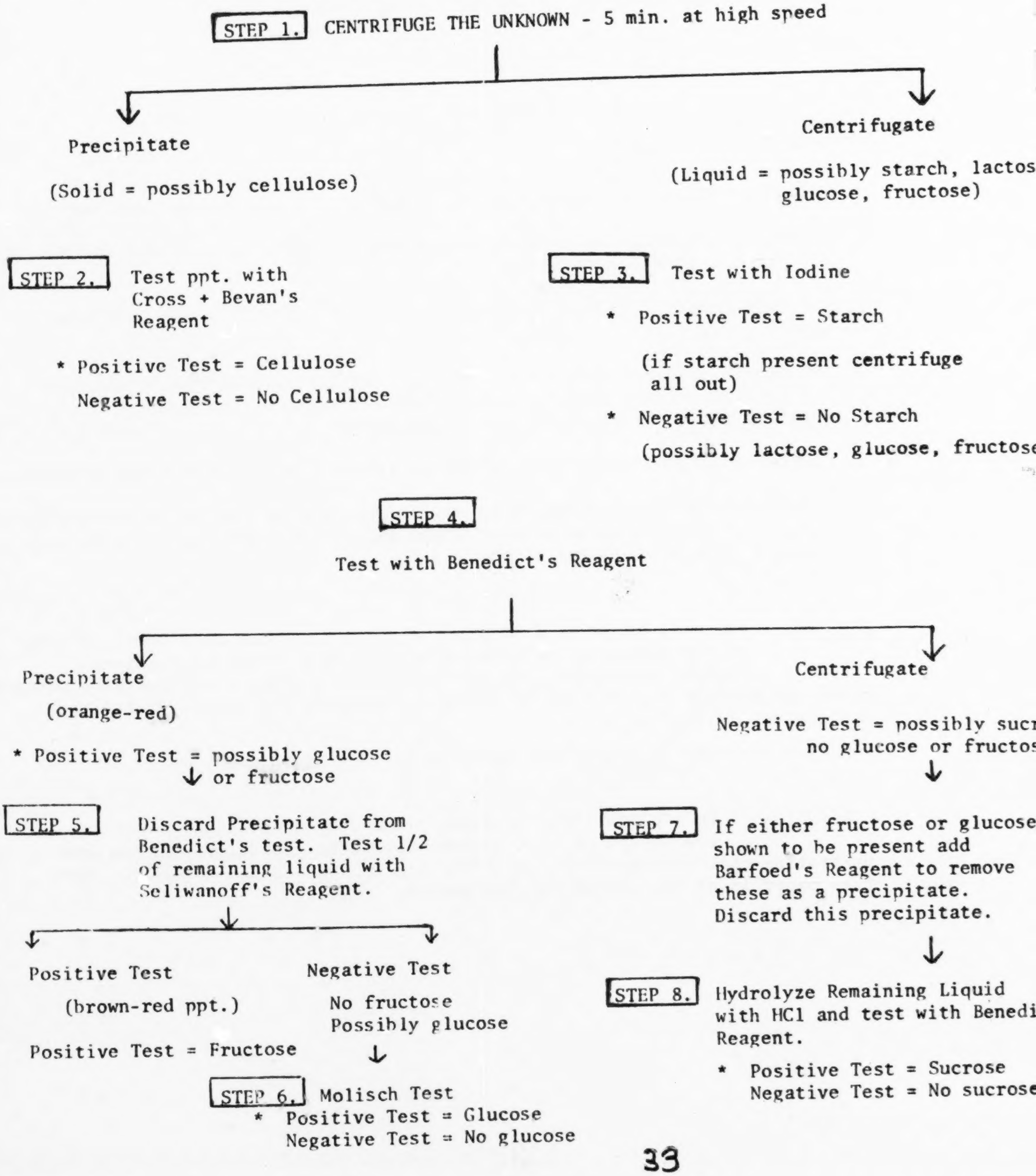
6. Cellulose forms a suspension in water which may be removed by centrifuging. This will go into solution when Cross and Bevan's Solution is added and reprecipitated by adding alcohol.

PROBLEM: You will be given a solution which may contain any, some, or none of the following carbohydrates: Glucose, Fructose, Lactose, Starch, Cellulose. On the basis of the above facts devise a procedure which you believe may be used to correctly identify the carbohydrates that are present in your solution.

The flow diagrams on page 23 may help you in your identification.

CONCLUSION: On a plain sheet of paper place your name, class, hour and the NUMBER OF YOUR UNKNOWN SOLUTION. Identify your unknown by stating what carbohydrates you think are present in the solution. Hand this paper in at the end of the lab period.

FLOW DIAGRAM FOR THE IDENTIFICATION OF CARBOHYDRATE



POSSIBLE CONTENTS = CELLULOSE, STARCH, SUCROSE, GLUCOSE, FRUCTOSE

STEP 1. CENTRIFUGE THE UNKNOWN - 5 min. at high speed

Precipitate

(Solid = possibly cellulose)

Centrifugate

(Liquid = possibly starch, lactos
glucose, fructose)

STEP 2. Test ppt. with Cross + Bevan's Reagent

* Positive Test = Cellulose
Negative Test = No Cellulose

STEP 3. Test with Iodine

* Positive Test = Starch

(if starch present centrifuge all out)

* Negative Test = No Starch

(possibly lactose, glucose, fructose

STEP 4.

Test with Benedict's Reagent

Precipitate

(orange-red)

* Positive Test = possibly glucose or fructose

Centrifugate

Negative Test = possibly sucr
no glucose or fructos

STEP 5. Discard Precipitate from Benedict's test. Test 1/2 of remaining liquid with Seliwanoff's Reagent.

Positive Test

(brown-red ppt.)

* Positive Test = Fructose

Negative Test

No fructose
Possibly glucose

STEP 6. Molisch Test

* Positive Test = Glucose
Negative Test = No glucose

STEP 7. If either fructose or glucose shown to be present add Barfoed's Reagent to remove these as a precipitate. Discard this precipitate.

STEP 8. Hydrolyze Remaining Liquid with HCl and test with Benedi Reagent.

* Positive Test = Sucrose
Negative Test = No sucrose

Exercise - Based on
Required Reading

Name ______________________________

Science IIA Hour ____

Date ______________________________

1. Write a general equation for the hydrolysis of a protein (specify any special conditions that are needed).

2. What is the difference between denaturation of a protein and hydrolysis of a protein?

3. You are given a protein. How would you analyze the protein for amino acid content?

4. Discuss the structure of a protein.

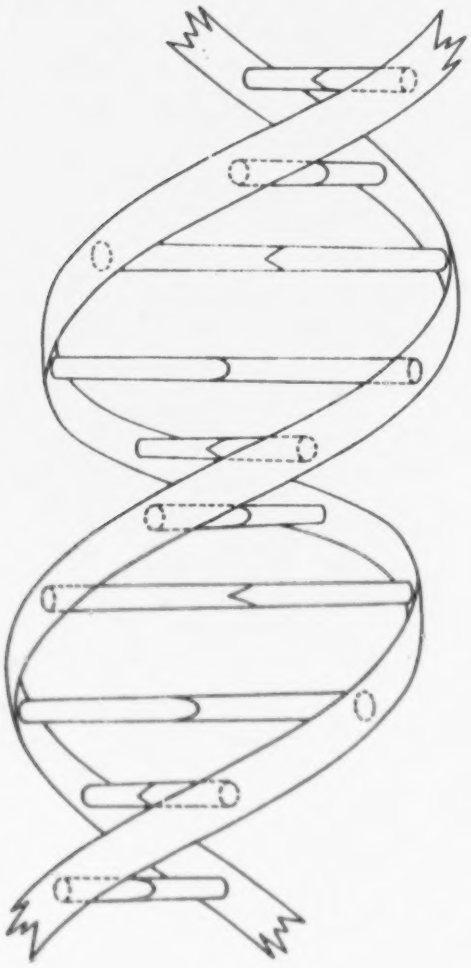
5. What property about nucleic acids makes them likely candidates for being used as a replication mechanism?

6. What is the definition of an organic molecule?

7. How would you identify a disaccharide?

8. Why is it that of the organic molecules studied fats can store the most energy?

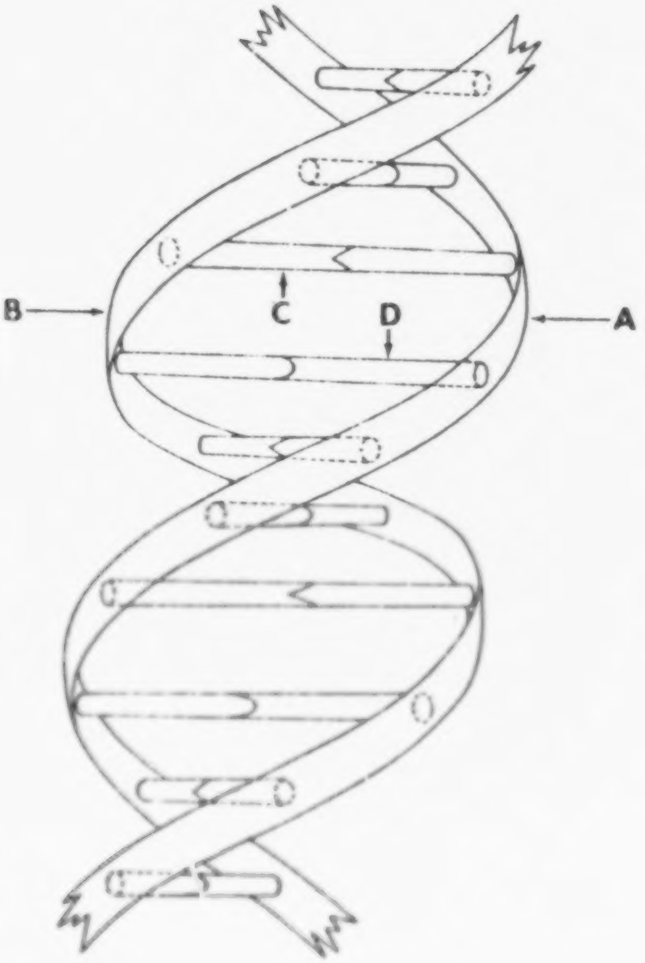
A REVIEW OF THE STRUCTURE OF THE NUCLEIC ACID, DNA



DIRECTIONS: The following pages contain a learning device known as a program. This program is designed to teach you some complex ideas in a series of small steps. As you answer each step be sure that the answer column is covered. When you have completed a page, check your answers. You will find that you will have few wrong answers. Check over any questions which you get wrong and see where you made errors.

Science IIA

PROGRAM - The Structure of the Nucleic Acid, DNA



THE WATSON-CRICK MODEL OF DNA

Fig. 1

A DO-IT-YOURSELF MODEL OF THE DNA MOLECULE

Source: "Science Activities", Oct, 1969

The DNA Molecule

Watson and Crick concluded that the DNA molecule consists of two strands twisted about one another in the form of a double helix. This double helix can be visualized as twisting a "ladder" with flexible uprights. The uprights of this "ladder" are made of phosphate and deoxyribose. The rungs of this "ladder" are made of purines and pyrimidines held together at the middle of each rung by hydrogen bonds.

Construction of the DNA Model

The following materials are needed per student or per group of students:

1. Six large paperclips (three sprayed red and three sprayed blue).
2. Six small paperclips (three sprayed red and three sprayed blue).
3. Six long or wide rubber bands.
4. Six short or narrow rubber bands.
5. Six notebook reinforcements.
6. Two pencils or two tongue depressors (used to hold the ends of the model).
7. One small envelope (used to store the above material).

The construction of the model can be approached in different ways, depending upon the ability of the students and how well informed they are about the DNA molecule. Students familiar with DNA structure can be given the envelope containing the above material and instructed to assemble it in a manner to best represent the DNA molecule

The writer feels that the materials assembled in the following manner will illustrate some of the basic properties of the DNA molecule. The "ladder" of DNA can be constructed by using all of the materials in the envelope. The flexible uprights of the "ladder" can be represented by the long and the short rubber bands. The long rubber bands can represent phosphate and the short rubber bands can represent deoxyribose in the model of the molecule. Two identical uprights should be constructed using at least three long rubber bands and two short rubber bands for each upright of the "ladder." The rubber bands can be put together by a half-hitch arrangement.

Each rung of the "ladder" is made up of a purine and a pyrimidine joined at the middle by a hydrogen bond. The large paperclips represent purines and the small paperclips represent pyrimidines. In the pairing of the purines and the pyrimidines, adenine pairs with thymine and guanine pairs with cytosine. The colors of the paperclips can be used to properly match the purines and the pyrimidines. The large red paperclip (adenine) pairs with the small red paperclip (thymine). The large blue paperclip (guanine) pairs with the small blue paperclip (cytosine). The paperclips should be connected to the short rubber bands of each upright at every other intersection of the long and the short rubber bands. This connection can be made by threading the open end of the paperclip through the knot formed by the half-hitch between the long and the short rubber bands.

29 In the DNA molecule the two strands are held together by hydrogen bonds. In this model the two uprights are held together by notebook paper reinforcements. Each reinforcement is threaded through on one side by a large paperclip and threaded through on the other side by a small paperclip. By this arrangement, the notebook paper reinforcement represents the weakest link in the model just as the hydrogen bond represents the weakest link in the DNA molecule. The replication of DNA can be illustrated by cutting the notebook paper reinforcements with scissors and building a matching new strand with paperclips and rubber bands.

The two pencils or tongue depressors can be used to hold and maneuver the model after it is constructed. The completed model is shown in Figure 3. The depressors or pencils are run through the pairs of long rubber bands at each end of the model. Now the model can be picked up and twisted to better illustrate the double helix form.

Summary

This inexpensive model of the DNA molecule has practical applications to the high school biology class. When properly constructed, the model can illustrate several of the properties of the DNA molecule. The materials for construction are inexpensive and they are usually available in any classroom. Finally and most importantly, if properly utilized, the model can stimulate the high school student to be creative by allowing him to construct his own design to best represent the molecule of DNA

References

Allfrey, V. C. and Mirsky, A. 1961. "How Cells Make Molecules," Scientific American, Vol. 205, No. 3, 74-82.

Crick, F. H. C. 1966. "The Genetic Code: III," Scientific American, Vol. 215, No. 4, 55-62.

CELLS - THE FUNDAMENTAL STRUCTURAL UNITS OF LIVING MATTER

Historical Development of the Cell Theory

Required Reading:	BSCS Yellow Version - pp 47-57 or 40-53
	BSCS Blue Version - pp 231-243
Recommended Reading:	Great Experiments in Biology, Gabriel and Fogel, "The Cell Theory", pp 1-24 and 574-611.
	The Microbe Hunters, Paul DeKruif, Ch. I "Leeuwenhoek, the First of the Microbe Hunters."
	The History of Biology, Eric Nordenskiold

I. Statement of the Modern Cell Theory

II. The Cell Theory was the Work of Many Men Spanning Over 200 Years

A. Robert Hooke - English physicist, 1635-1703

B. Theodor Schwann - German physiologist, 1810-1882

C. Robert Brown - Scottish botanist, 1773-1858

D. Matthias Jakob Schleiden - German botanist, 1804-1881

E. Karl Theodor Ernst Siebold - German zoologist, 1804-1885

F. Rudolph Virchow (fihr´koh) - German pathologist, 1821-1902

III. The Development of the Cell Theory Depends Upon Technological Inventions

A. Lenses - the Light Microscope

B. Microtechnique - the preparation and staining of slides

C. Tissue Culture - live cells

D. Electron Microscope

CELLS - THE FUNDAMENTAL STRUCTURAL UNITS OF LIVING MATTER, Continued

Cellular Structure and Function

I. All Cells Have Certain Structures in Common

A. The Cell Membrane - an enclosing sac

B. The Cytoplasm - a colloid containing microstructures

1. the Endoplasmic Reticulum

2. the Ribosomes

3. the Golgi Complex

4. the Mitochondria

5. Vacuoles and Granules

C. The Nucleus - the sit of information

II. Animal and Plant Cells Differ

A. The Cell Wall - for plants only

B. The Chloroplast - also for plants only

III. Cells Specialize - the structure of a cell is designed for a particular function.

Examples:

A. the nerve cell

B. the red blood cell

C. a white blood cell

D. skin cells

IV. Cells Organize

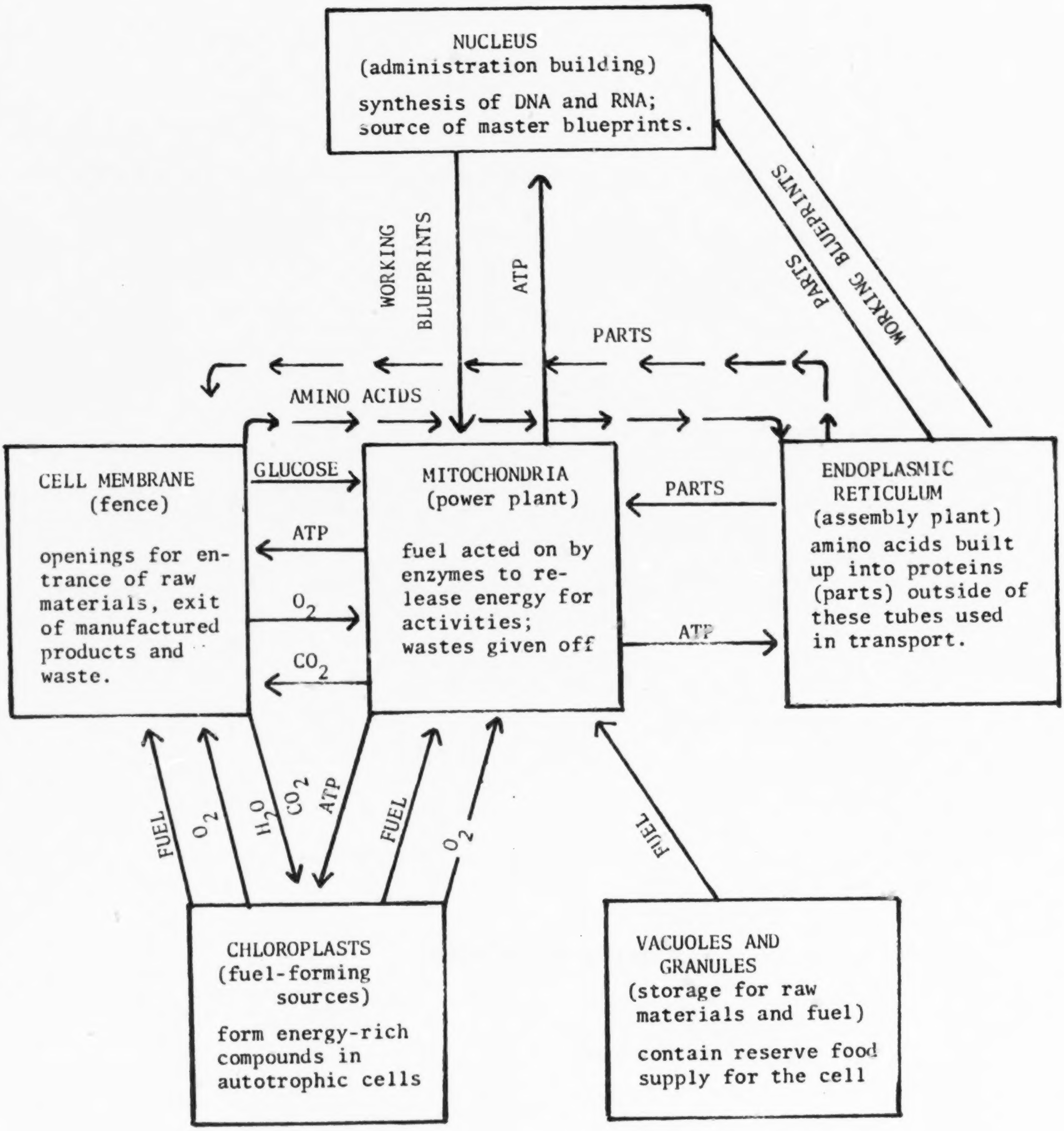
A. Tissue - eg. cardiac muscle tissue

B. Organ - eg. the heart

C. System - eg. the circulatory system

D. Organism - eg. man, dog, fish, etc.

35 THE CHAIN OF COMMAND FOR ACTIVITIES WITHIN THE "CELL FACTORY"


NUCLEUS
(administration building)
synthesis of DNA and RNA; source of master blueprints.
WORKING BLUEPRINTS
ATP
PARTS
WORKING BLUEPRINTS
PARTS
AMINO ACIDS
CELL MEMBRANE
(fence)
openings for entrance of raw materials, exit of manufactured products and waste.
GLUCOSE
ATP
O_2
CO_2
MITOCHONDRIA
(power plant)
fuel acted on by enzymes to release energy for activities; wastes given off
PARTS
ATP
ENDOPLASMIC RETICULUM
(assembly plant)
amino acids built up into proteins (parts) outside of these tubes used in transport.
FUEL
O_2
H_2O
CO_2
ATP
FUEL
O_2
FUEL
CHLOROPLASTS
(fuel-forming sources)
form energy-rich compounds in autotrophic cells
VACUOLES AND GRANULES
(storage for raw materials and fuel)
contain reserve food supply for the cell

MASTER BLUEPRINTS = DNA code
WORKING BLUEPRINTS = transfer (messenger) RNA

Exercise

CELL STRUCTURES AND FUNCTIONS

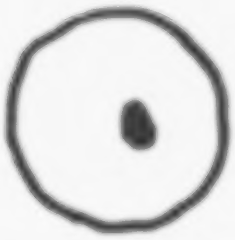
(Source = EMI Programed Biology Series)

Part I.

DIRECTIONS

Covering the answer below the dark line, write in the answer in the space provided. After you have written your answer you may check it.

1.

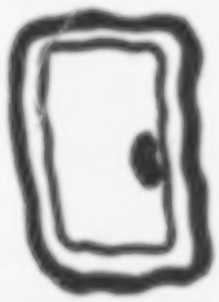


The thin, living outer boundary of the cell labeled A is the ______________________.

---

plasma membrane

2.

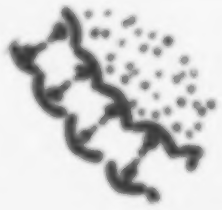


In plants, the plasma membrane is surrounded by a thick, nonliving ______________________.

---

cell wall

3. The plasma membrane, like other membranes in the cell is made up of a double layer of ________________ molecules sandwiched between two layers of ________________ molecules.



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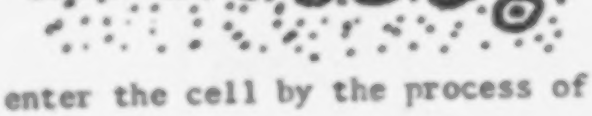
lipid; protein

4. Small molecules like water can enter and leave the cell through tiny ________________ in the plasma membrane.

---

pores

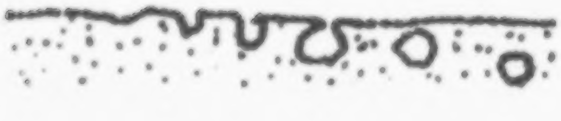


5. Larger molecules, as solid particles, can enter the cell by the process of "cellular eating" called ________________.

---

phagocytosis

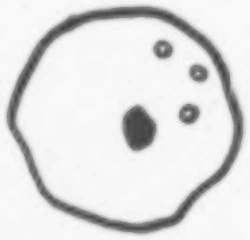
37



6. Larger dissolved molecules and water can enter the cell by the process of "cellular drinking" called ______________________________.

pinocytosis

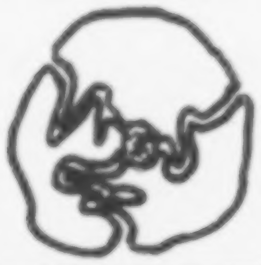
7.



Materials that enter by phagocytosis and pinocytosis are found in membrane-lined, watery "bubbles" called _________________________.

vacuoles

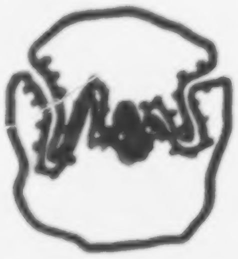
8.



At several points along its surface, the plasma membrane is continuous with a system of membrane-lined canals called the ________________________ ____.

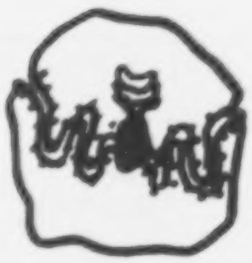
endoplasmic reticulum

9. Protein production takes place at bodies called ____________________________, which lie along the endoplasmic reticulum or free in the cytoplasm.



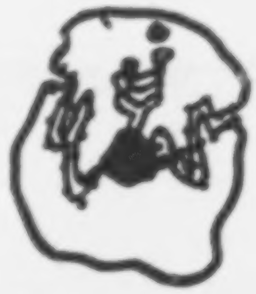
ribosomes

10. Usually near the nucleus some membranes of the endoplasmic reticulum form a cup-shaped stack of membrane-lined canals called the _______________ _________________________.



Golgi complex

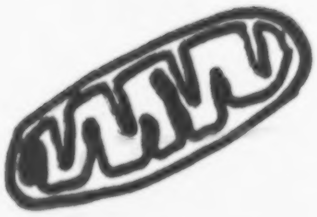
11.



The Golgi complex seems to collect and store molecules produced by the cell. Some of the digestive enzymes in the Golgi complex seem to be budded off in membrane-lined sacs to form ____.

lysosomes

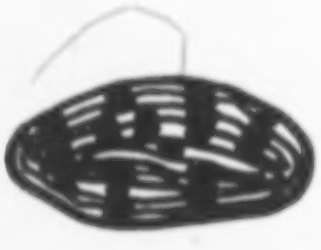
12.



The "powerhouse of the cell" that releases energy for cellular activities is a membranous structure called the ________________________________.

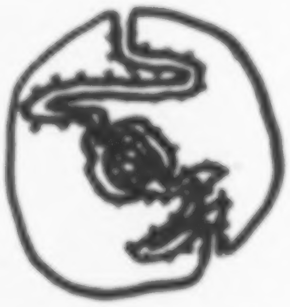
mitochondrion

13. Green plant cells contain a membranous structure for trapping light energy which is called the ______________________________.



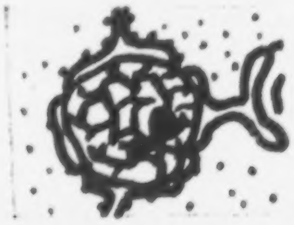
chloroplast

14. Membranes of the endoplasmic reticulum are spread out over the material of the nucleus to form a wall around the nucleus called the ________________________ ___________________.



nuclear membrane

15.

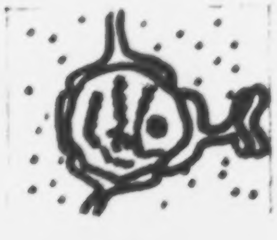


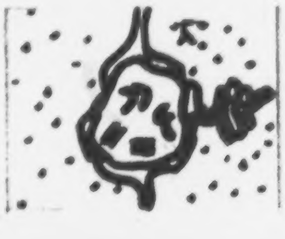
In the nondividing nucleus there can be seen a tangled network of darkly staining structures called ________________________.

chromatin

16. The chromatin network consists of the darkly staining parts of individual threads called ___________________________.

What happens to these "threads" as the nucleus divides?





chromosomes; They coil and become entirely visible.

17. The RNA produced by the chromosomes is stored in a darkly staining sphere in the nucleus called the ______________________.

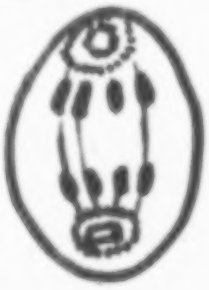
nucleolus

18.

The RNA produced by the ______________________ ______________________- and stored in the ______________________ then goes to the cytoplasm where its function is to ______________________ ______________________.

chromosomes (or DNA of the chromosomes); nucleolus; control the production of protein.

19.



When animal cells divide, the parts of the dividing nucleus are pulled to opposite ends of the cell by protein fibers extending from the ______________________

centrioles

20. A separate working part of our body (like the heart) is called an organ, and -elle means "little," so the little separate working parts of the protoplast are called ______________________.

organelles

Quiz

Part II

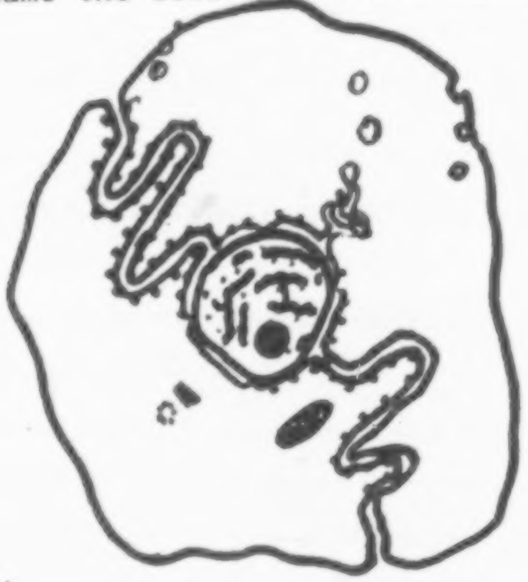
Name ______________________________

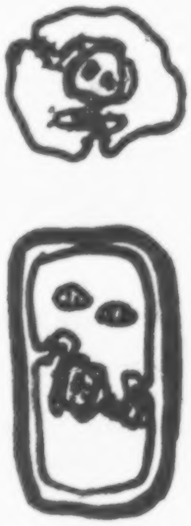
Science IIA Hour _____

Date ______________________________

CELL STRUCTURES AND FUNCTIONS

Name the cell organelles indicated in the drawings below:





A. ______________________________

B. ______________________________

C. ______________________________

D. ______________________________

E. ______________________________

F. ______________________________ _____

G. ______________________________

H. ______________________________

I. ______________________________

J. ______________________________

K. ______________________________

L. ______________________________

M. ______________________________

N. ______________________________

O. ______________________________

P. ______________________________

Name the structure that fits each description below:

(a) controls what materials enter and leave the cell ______________________________

(b) process of "cellular eating" that enables solid particles to enter the cell ______________________________

(c) process of "cellular drinking" that takes water and dissolved materials into the cell ______________________________

(d) a membrane-lined, watery "bubble" in the cell that may store water, food, or wastes ______________________________

(e) the cell's "road system" for transporting materials throughout the cell ______________________________

(f) site of protein production ______________________________

(g) cup-shaped stack of membrane-lined canals that collects, stores, and helps to distribute products produced by the cell ______________________________

____

(h) bag of digestive enzymes ______________________________

(i) "powerhouse of the cell" where energy is released in respiration ______________________________

____

(j) site where light energy is trapped for use by green plant cells in photosynthesis

____

(k) the "threads" of DNA that make RNA and thus control the growth and reproduction of the cell ______________________________

(l) tangled network of darkly staining structures visible in the nondividing nucleus ______________________________

(m) structures whose protein fibers pull apart the parts of the nucleus during cell division ______________________________

(n) structure that separates the cytoplasm from the nucleus ______________________________

____

(o) liquid portion of the nucleus ______________________________

Required Reading: BSCS Green Version, Chapter 20, "Man In The Web of Life"

Recommended Film Strips: "Populations and Biomass" - McGraw-Hill
"Adaptation to Environment" - McGraw-Hill

I. Some definitions:

   A. Populations

   B. Community

   C. Ecosystem

   D. Biome

II. Some Activities Which Could Be Performed In An Ecological Study.

   A. Basic Studies to be Made -

      1. Study of Habitat
         Light - duration and intensity

         Temperature - general, daily readings

         Humidity - general, daily readings

Soil Profile - depth of zones present

Soil Moisture - content and capacity

Soil Tests - pH; phosphorous; nitrogen, potash

Water - if stream, bog or pond present:
clarity; pH, rate of flow; depth

Topography - scale map

2. Study of Fauna -

   Special Detailed Study of One Species: life history, feeding, distribution, populations.

   Earthworm Population: sample + estimate

   Dung and Pellet Analysis: determine fauna not sun in area

3. Study of Flora -

   General Study of one species found

   Root Systems: depth, spread, storage, relation to drainage

   Vegetative Reproduction: types found

   Trees: cover, density, influence

pp 44-47

The material masked out on this page may be found:

Title Ecosystems

Author

Publisher American Biology Teacher

Page Number April, 1963

Data Sheet for Ecological Survey
(Source - "American Biology Teacher"
April, 1963)

Name ______________________

Science IIA Hour _____

Date ______________________

ECOLOGICAL SURVEY

Plot No. ________ Location: ______________________ Forest Type: ____________

Topography: ____

Fungus and Insect Damage: ____

Evidence of Fauna: ____

Weather Damage: ____

Plant Sampling

Plant	No. Plants in 28" Circle										Total	Freq.	Abund.
	1	2	3	4	5	6	7	8	9	10			

Algae: ____

Fungi: ____

Lichen: ____

Moss: ____

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Soil Characteristics

Profile:

Horizon Thickness pH

1. clay______, loam______, sandy-loam_____ sand_____ gravel__________
2. poorly drained_____, well drained_____, very well drained_______
3. wet_____, moist_____, fresh_____, dry_____

Field Capacity____________________________

Other____
____
____

PARTICLE KINETICS, IN FLUID SYSTEMS

Recommended Reading: *How Life Began*, Adler, 101-108

INTRODUCTION:

Before two atoms or molecules can interact and experience changes in their chemical composition there must be physical contact between the particles. That is, the particles must come together for a sufficient amount of time to permit the chemical reaction to occur.

For substances which are in solution the opportunity to interact and change chemically is influenced by a number of factors. For one thing, the probability of two particles colliding, and thus providing the opportunity for the exchange or sharing of electrons, is improved if there is a large number of the particles present in the solution. Thus we can see that the concentration of a solution has a great bearing on the rate of the reaction which may take place. Secondly, since the probability of collision is also greater with high velocities, such things as temperature and pressure have a pronounced effect on the rate of reaction.

Chemical reactions are also affected by the nature of the reactant itself, the size of its surface area, the presence of catalysts and even the nature of the solvent in which the particles are suspended. Since most chemical reactions do occur in solutions, especially those associated with life functions, it is appropriate that we investigate the nature of solutions and the factors which affect chemical reactions in solutions before we become involved in a more detailed study of the characteristics of living matter and the mechanisms of life functions.

CHARACTERISTICS OF PARTICULATE FLUID SYSTEMS

Required Reading: Modern Chemistry, pages 260-267 and 464-483

Recommended Reading: How Life Began, Adler, pages 101-108

I. Solutions

- A. Nature of solutions
    1. True solution--a homogeneous mixture of two or more substances, the composition of which may be varied within definite limits
    2. Suspension
    3. Colloid
    4. Components
        - a. Solvent--dissolving medium
        - b. Solute--substance dissolved
- B. Types of solutions

	Solute	Solvent	Example
1.	Gas	Gas	
2.	Gas	Liquid	
3.	Gas	Solid	
4.	Liquid	Gas	
5.	Liquid	Liquid	
	a. Miscible		
	b. Immiscible		
6.	Liquid	Solid	
7.	Solid	Gas	
8.	Solid	Liquid	
9.	Solid	Solid	

- C. Solution equilibrium
    1. Degree of saturation

        a. Unsaturated

        b. Saturated

        c. Supersaturated

    2. Solubility--the amount of solute dissolved in a given amount of a certain solvent at equilibrium, under specified conditions

    3. Dynamic physical equilibrium

  D. Properties of solutions

    1. Effect of pressure on solubility

        a. Gases in liquids

        b. Solids in liquids

    2. Effect of temperature on solubility

        a. Gases in liquids

        b. Solids in liquids

    3. The solubility curve

    4. Factors affecting the rate of solution

    5. Expressing concentration

  E. Solution mechanisms

II. The Colloidal State

  A. Colloidal suspensions

  B. Range of colloidal size

  C. Types of colloidal suspensions

    1. Lyophobic

    2. Lyophilic

  D. The nature of adsorption

  E. The properties of colloids

    1. Suspensoids

    2. Emulsoids

III. Particulate Fluid Systems in Nature

A. Familiar examples of Fluid Systems

1. True Solutions

2. Colloids

3. Suspensions

B. The Importance of Fluid Systems to Living Organisms

CHARACTERISTICS OF PARTICULATE FLUID SYSTEMS

Solutions, Colloids, and Suspensions

GENERAL PURPOSE:

To study the properties of solid-liquid systems

INTRODUCTION:

Solid-liquid systems are organized in several ways. These are usually classified as solutions, colloids, or suspensions. This investigation is designed to illustrate some ways to show the more obvious differences among the three types of systems. These can be shown by comparing each of the systems with respect to: (1) a beam of light; (2) a membrane; (3) settling; (4) filtration; (5) the ability to form gels.

Four test liquids will be used.

Sample A: NaCl + H_2O

Sample B: Gelatin + H_2O

Sample C: Fine Sand + H_2O

Sample D: Fine Clay + H_2O

Label four test tubes (A, B, C, D) and fill with the appropriate test liquid. Set test tube D aside for future use and reference.

PROCEDURE:

1. Test the reaction of test liquids A, B, and C to a beam of light. To do this, place each test tube in the path of a beam of light. Note how each test liquid affects the beam. Record whether the beam is the relative degree of the visibility and the presence of an opalescence (milky appearance) to the beam of light.

2. To test the behavior of the test liquids with respect to movement through a membrane, fill each of three sausage casings with one of the solutions. Your teacher will tell you how to fill and tie the casings. Suspend each casing separately in a test tube of distilled water so that the casing lies beneath the surface of the water. Allow each casing to stand 15-20 minutes.

   After this time, take about one or two ml of the distilled water into which casing A was suspended. Test this with silver nitrate, which is the specific test for the chloride ion of the sodium chloride. If sodium chloride particles did penetrate the membrane, a white precipitate will result.

   Next, take 1 or 2 ml of water from the test tube in which casing B was placed. Test this for the presence of protein, since gelatin is a proteinaceous material. To test for protein add 2 or 3 ml of (Biuret Reagent). The presence of a protein is indicated by the appearance of a yellow color. In the third test tube you can easily notice whether any sand particles appear outside the casing. Record those materials which came through the membrane.

3. To see whether settling occurs in any of the test tubes, simply place a sheet of white paper under each test tube. Any particles of solute that may have accumulated at the bottom of the test tube can then be seen. Note those test tubes in which settling was observed.

4. To test whether the mixtures can be filtered without change, pour each one through a separate sheet of filter paper. Set up three glass funnels on a funnel rack. Put a piece of filter paper in each one (ask your teacher how to fold the filter paper if you do not know how). Place a receptacle, such as an evaporating dish, under each funnel. Using a separate funnel for each test liquid, pour the mixtures into the funnels and allow them to filter through. Record the materials where particles of solute were left behind.

5. The capacity to change from the sol state into a solid, or gel, state is characteristic of some types of colloids, as in the solidifying of Jello. To determine whether any of the test liquids is colloidal, take about 20 to 25 ml of each liquid and place in a separate evaporating dish. Heat the material in each dish to near boiling and allow to cool. After sufficient time for cooling has elapsed, determine which solution gelled. Reheat the gelled material. Note which of the test liquids gelled, whether reheating affects the gelled liquid and how the liquid is affected.

6. Take the test liquid in test tube D that you set aside at the beginning of the exercise. Be careful not to agitate the liquid. Subject the test liquid to all the tests that you did on A, B, and C and record the results.

Name ____________________

Science IIA Hour _____

Date ____________________

Test Liquid	Beam of Light	Behavior with respect to a membrane	Settling Effect	Filtration	Ability to form Gels	Reheating	Is Test Liquid a Solution, Colloid, Suspension or Combination?
A Sodium Chloride and Water							
B Gelatin and Water							
C Sand and Water							
D Fine Clay and Water							

CHARACTERISTICS OF PARTICULATE FLUID SYSTEMS

QUESTIONS FOR CONSIDERATION:

1. Why do some materials penetrate a membrane such as sausage casing and others do not?

2. What is the relation of particle size to determining whether a substance is a colloid or a suspension?

3. What fact might cause it to be difficult to determine whether a material is a colloid or a suspension?

4. Explain why an understanding of particulate fluid systems is essential to developing an understanding of living matter.

5. Explain the difference between a colloid and a suspension.

6. What is the difference between an emulsoid and a suspensoid.

SOLUTIONS - THE MEDIUM IN WHICH THE MATTER-ENERGY INTERACTIONS OF LIFE OCCUR

I. The Physical Basis for Chemical Change

A. Solid - Solid interactions

B. Interactions between matter in mixed states

C. Interactions in solution

D. Interactions between gases

II. Methods of Expressing Solution Concentrations

A. Density

B. Specific Gravity

C. Percent Strength

59

D. Molarity

1. Molecular weight

2. Gram molecular weight - "mole"

3. molar solutions

E. Normality

1. Equivalent weight

2. Gram equivalent weight

3. Normal solutions

Problem Exercise

Name ____________________

Science IIA Hour _____

Date ____________________

Methods of Expressing Solution Concentration

1. A particular salt solution, having a volume of 240 ml was found to weigh 248 grams. Calculate the density of the solution.

2. Thirty-two grams of potassium chloride was dissolved in 75 grams of water. Calculate the percent strength of the solution.

3. Twenty-six ml of a certain solution was found to weigh 24 grams. Calculate its SpGr.

4. How many grams of sugar would have to be dissolved in 50 grams of water to make the concentration 15%?

5. Fifty-four grams of a 16% solution of magnesium nitrate were evaporated to dryness. The heat of the reaction did not decompose the salt or cause it to vaporize. Calculate the number of grams of $Mg(NO_3)_2$ that were obtained.

6. How many grams of K_2SO_4 will be required to prepare two liters of a 0.5M K_2SO_4 solution?

7. How many grams of $Al_2(SO_4)_3$ would be required to make up 400 ml of a 2N solution of aluminum sulfate.

8. A 14% solution of Na_2CO_3 in water has a specific gravity of 1.5. How many cubic centimeters of this solution must be evaporated to obtain 12 grams of dry sodium carbonate?

9. In 3.58M H_2SO_4 there is 29% H_2SO_4. Calculate the density of this sulfuric acid solution.

10. Concentrated HCl has a specific gravity of 1.19. Its percent strength is 37%. How many ml of this acid solution would be required to prepare 400 ml of a 0.5 N solution?

TECHNIQUES FOR DETERMINING SOLUTION CONCENTRATION

I. Weight- volume methods

    A. The basic problem

    B. Procedures

        1. By isolating the solute from the solvent

            a. techniques

            b. problems

        2. Without isolating the solute

            a. techniques

            b. problems

II. Titration Techniques

A. Theory of titration

1. normality

2. the idea of "Equivalence"

3. titrating standards

B. The techniques of Titration

1. use of the titrating buret
    - a. mounting
    - b. operation
    - c. reading scales

2. Operational Techniques
    - a. selection of titrating standard
    - b. initial titration
    - c. final titration

3. Care of Equipment

   a. cleaning the buret

   b. storage

4. Use of Dropping Pipettes

   a. types of dropping pipettes

   b. technique for transfering solutions

III. Use of Indicators

A. Non-quantitative color indicators

B. Semi-quantitative color indicators

65

IV. Electrical Methods

A. pH meter

B. colorimeter

C. electrical conductivity

Laboratory Problem

STRENGTH OF SOLUTIONS

INTRODUCTION:

Five different methods for describing the concentration of solute in a solution have been discussed. Each one has unique advantages in describing concentrations for specific purposes and for varying conditions. Although each of these techniques describes the solution concentration in different ways, each one of them takes into account the relative quantity of solute and solvent. Therefore, the various expressions are equivalent. For example, if the normality of a solution is known it is possible to calculate the molarity, density, specific gravity, and the percent strength of the same solution. In the laboratory problem you will be given a solution containing a known solute. Based on your understanding of the definitions which describe solution concentration and your working knowledge of the techniques used to determine solution concentration, you are to determine the density, specific gravity, % strength, normality, and the molarity of the solution.

PROBLEM:

To make a quantitative analysis of a solution containing an unknown quantity of a known solute and determine the Density, Specific Gravity, Percent Strength, Normality, and Molarity of the solution.

PROCEDURE:

There are at least four different basic procedures by which it is possible to make a quantitative analysis of the strength of a solution. These procedures are:

1. weight-volume methods
2. titration against a known standard
3. measurement of pH
4. measurement of electrical conductivity

Not all of these procedures can be used with all solutions. For example: electrical conductivity can only be used to determine the strength of a solution which contains ions and this method requires a knowledge of the ionization constant for the solute. Procedures #2 and #3 are appropriate only when the solute is an acid or base. The weight-volume method, depending upon the actual procedures followed, can be used to determine the strength of any solution. By this method the problem is to determine the weight of solute contained in a known volume of the solution. If one plans to isolate the solute by evaporative techniques it must first be established that the solute will not be decomposed by heating or escape as a gas or vapor during the evaporation process. It is possible, however, to determine the weight of solute in a solution without separating the solute from the solvent

In this laboratory problem you are to work with a partner and establish your own procedure for determing the concentration of the solution. Once the weight of solute in a known volume of the solution has been determined and the chemical formula of the solute is known one can readily calculate the solution Density, Specific Gravity, % Strength, Normality, and Molarity. Include an outline of the procedure followed in the procedure section of your report.

DATA:

Number of Unknown ________

Chemical Formula of Solute _______

Volume of Solution Analyzed ________

Additional Data Required will depend upon the procedure followed! After having decided upon a procedure to follow prepare a data sheet which clearly specifies all the information that will be required in order to use the procedure decided upon to solve the problem. Arrange this information in a meaningful way on your data sheet and use this data sheet as a guide during the course of your experiments. A copy of this data sheet should be included in your report.

INTERPRETATION OF DATA:

In this part of your report show how you have used your data to calculate

DENSITY = =

SPECIFIC GRAVITY =

% STRENGTH =

NORMALITY =

MOLARITY =

* do all calculations on scratch paper and report all answers in the conclusion

CONCLUSION:

Your conclusion should specify:

NUMBER OF UNKNOWN ____________

DENSITY ____________

SPECIFIC GRAVITY ____________

% STRENGTH ____________

NORMALITY ____________

MOLARITY ____________

INTERACTIONS THAT OCCUR WITHIN FLUID SYSTEMS

Interactions Involving Chemical Change

Required Reading: Modern Chemistry, pages 281-290

QUESTIONS FOR CONSIDERATION:

1. What is the difference between "ionization" and "dissociation"? What kinds of chemical compounds "dissociate" in water? What kinds of compounds "ionize" in water?

2. How do you account for the fact that the continued addition of distilled water to glacial acetic acid, both of which are non-conductors, results in the increasing conductance of the final solution?

3. Carbon tetrachloride, CCl_4, is not soluble in water. Ethyl alcohol, C_2H_5OH is soluble in both CCl_4 and water. How is this phenomena explained? Consider the structure of these molecules in your explanation.

4. By what method, other than dissolving in water, could the ions of NaCl be separated?

5. Svante Arrhenius, the brilliant Swedish chemist, published his theory of ionization in 1887. Why is this paper considered to be such an outstanding achievement?

INTERACTIONS INVOLVING CHEMICAL CHANGE

I. The Theory of Ionization

A. Conductance of solutions

B. Dissociation of Ionic Compounds

1. Structure of ionic compounds

2. Hydration of ions

C. Ionization of covalent compounds

1. Polar covalent compounds

IONIZATION AND DISSOCIATION GUIDE

TYPE OF COMPOUND (BOND)	IONS PRESENT IN PURE SUBSTANCE	ACTION BY H_2O	EXAMPLE	DISSOCIATION OR IONIZATION EQUATION
I. Ionic Compounds (ionic bonds)	Yes	Dissociation		
A. Salts			$Zn_3(PO_4)_2$	$Zn^{+2}_3(PO_4)^{-3}_2 \rightarrow 3\ Zn^{+2} + 2\ PO_4^{-3}$
B. Bases (hydroxides)			$Ca(OH)_2$	$Ca^{+2}(OH)^{-1}_2 \rightarrow Ca^{+2} + 2\ OH^{-1}$
II. Covalent Compounds (covalent bonds)	No	Ionization		
A. Polar Covalent - 100% ionization (strong acids)			H_2SO_4	$H_2SO_4 \rightarrow 2\ H^{+1} + SO_4^{-2}$
B. Polar Covaelnt - partial ionization				
1. Weak Acids			$HC_2H_3O_2$	$HC_2H_3O_2 \rightleftarrows H^{+1} + C_2H_3O_2^{-1}$
2. Weak Bases			NH_4OH	$NH_4OH \rightleftarrows NH_4^{+1} + OH^{-1}$
3. Water			H_2O	$H_2O \rightleftarrows H^{+1} + OH^{-1}$
C. Carbon Compounds - no ionization		none	CCl_4, C_2H_5OH	

2. The degree of ionization

3. Substances which do not ionize

D. The hydronium ion

E. Strong and weak electrolytes

F. Ionization of the water molecule

Exercise

Name ____________________

Science IIA Hour _____

Date ____________________

THE THEORY OF IONIZATION

1. Give a definition of an ion.

2. What difference exists between an atom and an ion?

3. State the essential assumptions of the modern theory of ionization.

4. Describe the action of the water dipole in separating the ions of the sodium chloride crystals when they are dissolved in water.

5. Describe the action of the water dipole in ionizing the hydrogen chloride molecule.

6. What is the difference between dissociation and ionization.

7. Give definitions of:
    a) dilute
    b) concentrated
    c) strong
    d) weak
    e) hydration of ions

8. Give the definition and formula for the hydronium ion.

9. What substances when placed in water give rise to the hydronium ion?

10. Why does CCl_4 not ionize?

11. Write the ionization or dissociation equations for the following substances.

    a) HCl

    b) $NaCl$

    c) $NaOH$

    d) H_2SO_4

    e) H_3PO_4

    f) $HC_2H_3O_2$

    g) NH_4OH

    h) $NH_4C_2H_3O_2$

    i) $MgCl_2$

    j) $Ca(NO_3)_2$

    k) $Ca(OH)_2$

    l) H_2O

REACTIONS INVOLVING ACIDS, BASES AND SALTS

Required Reading: Modern Chemistry, pages 294-306 and 310-313

QUESTIONS FOR CONSIDERATION:

1. From a chemical point of view what is the difference between compounds which are called acids and those which are bases?

2. What is the difference between an acid and an acid anhydride? What kinds of compounds are acid anhydrides?

3. How is the strength of an acid or base expressed?

4. Why is a weak acid made stronger when water is added to it?

5. Explain why water with ammonium chloride gas dissolved in it is an acid and why pure NH_3 gas is an acid even though it has no ions.

6. Why are special precautions required when diluting concentrated sulfuric acid while no special procedure is necessary for other acids?

7. It is said that the consumption of H_2SO_4 is an index to the state of civilization and prosperity of a country. Explain the basis of this statement.

8. Do salts have electro-valent or co-valent bonds, or can they be either? Explain your answer.

INTERACTIONS INVOLVING CHEMICAL CHANGE, Continued

REACTIONS INVOLVING ACIDS, BASES, AND SALTS

I. Acids

A. Common Acids

B. Chemical Definition of an Acid

C. General Properties of Acids

II. Bases

A. Common Bases

B. Chemical Definition of a Base

C. Properties of Bases

III. pH - a Measure of Acid and Basic Solution Strength

A. Definition

B. The pH Scale

C. The pH of Common Substances

D. Indicators

IV. Salts

A. Definition - a compound made up of positive metallic ions or radicals bonded to negative ions

B. Common salts

C. Neutralization

Laboratory Investigation

ACIDS

GENERAL PURPOSE:

To study the properties and reactions of acids.

PROCEDURE:

1. Place hydrochloric acid, nitric acid and acetic acid in each of three small test tubes. Use acids directly from stock bottles. Compare the taste of hydrochloric and acetic acids by dipping stirring rods into the solutions and touching it to your tongue. DO NOT TASTE NITRIC ACID!
2. Test the action of each of the three acids on phenolphthalein, litmus and methyl orange by placing drops of acid on glass plates with the stirring rods. Fresh drops should be used for each indicator.
3. Put a small piece of zinc into each of the acid solution. Test the gas evolved.
4. Try litmus paper on dry boric acid and on boric acid dissolved in water.
5. Bubble your breath through some water using litmus paper as an indicator of a reaction.

Science IIA
Laboratory Investigation

BASES

GENERAL PURPOSE:

To study the properties and reactions of bases.

PROCEDURE:

1. Test the action of litmus paper and phenolphthalein on solutions of sodium hydroxide and ammonium hydroxide. Use bases directly from stock bottles.

2. Rub sodium hydroxide solution between the fingers. Wash off immediately!

3. Place solutions of sodium hydroxide and ammonium hydroxide in two separate small test tubes. Test the effect of methyl orange on the solutions.

4. Prepare $Ca(OH)_2$ from a small amount of CaO. Give proof that the reaction has occurred.

5. Prepare NaOH by placing Na metal on water, using proper precautions. Add two drops of phenolphthalein to the solution. Neutralize the solution with HCl and evaporate a few drops on a glass slide. Taste the residue.

6. Add a few drops of sodium hydroxide solution to a small amount of a solution of zinc sulfate.

Exercise

Name ____________________

Science IIA Hour ______

Date ____________________

ACIDS AND BASES

1. Name some organic acids and the foods that contain them

2. Fill out the following chart on the three important mineral acids.

Chemical name	Common name	Formula	Specific Gravity	Physical State	Uses

3. Give three reasons why boiling concentrated sulfuric acid produces especially serious burns.

4. What acid is found in the human body?

5. Why is sulfuric acid used to make all other acids?

6. What ion is produced by all acids and is responsible for the properties of all acids?

7. Why are pure sulfuric and nitric acid and liquid HCl poor conductors of electricity?

8. Write the ionization equations of nitric, sulfuric, hydrochloric and acetic acids.

9. Give a simple definition of an acid and the best modern definition of an acid.

10. What is the difference between a strong and weak acid?

11. What does adding water do to the concentration of a weak acid?

12. Write the theoretical symbol for a free proton and a hydrated proton.

13. Summarize the effect of acids on the common indicators.

14. Explain the difference you observed in the test of HCl and $HC_2H_3O_2$ and the difference you noted in their reaction on zinc. (Experiment on Acids, Procedures 1 and 3).

15. Explain your observation in Procedure 5 in the Experiment on Acids.

16. Explain your observation with dry boric acid and boric acid dissolved in water. (Experiment on Acids - Procedure 4).

17. Summarize the effect of bases on the common indicators.

18. Give the chemical formula and common name for some bases found in the home.

19. What is the characteristic feel and taste of a base?

20. What ion is responsible for the taste of a base?

21. Why did Procedure 6 in the Experiment on Bases have to be performed using water solutions?

COMBINATION, DECOMPOSITION AND NEUTRALIZATION REACTIONS

I. Combination type Reactions

A. Definition - a reaction in which two or more substances combine to form a more complex substance

B. General Equation

C. Examples:

1. Combination of Elements (formation of binary compound)

2. Combination of Compounds

a. Basic Anhydride + water

b. Acid Anhydride + water

c. A Special case; Ammonia + water

II. Decomposition

A. Definition - a reaction in which a complex substance breaks down to form two or more simpler substances

B. General Equation

C. Examples:

1. Electrolysis of Binary Compounds - Review

a. Generalization

b. Equations

2. Heating of Metallic Oxides - Review

   a. Generalization

   b. Equations

3. Heating of Metallic Chlorates - Review

   a. Generalization

   b. Equations

4. A Special Case - Decomposition of Ammonium Hydroxide

GENERAL TYPES OF CHEMICAL REACTIONS

PART I

GENERAL PURPOSE:

To study combination and decomposition reactions.

INTRODUCTION:

Directions for investigations are given below. Before beginning each investigation be sure that you understand the purpose for the activity and that you have written out a statement of this purpose. Record your observations immediately after performing an investigation and before going on to the next one. The specific conclusions are to be given when the experiment is written up. These conclusions are to include the chemical equations for each reaction.

PROCEDURE:

1. Burn a pinch of sulfur on the end of the spatula. Hold wet litmus paper (both colors) near the burning sulfur.
2. Burn a piece of magnesium ribbon by holding with a forceps, lighting in a burner and holding over an asbestos pad. Avoid looking directly at the burning magnesium. Place the product in an evaporating dish. Add a small amount of water and test with litmus paper.
3. Fill a small test tube one-third full with ammonium hydroxide. Hold wet litmus paper near the mouth of the tube as you warm the tube.
4. Heat a small amount of mercuric oxide in a dry, small test tube. Test for an evolved gas by holding a glowing splint near the mouth of the tube while heating.
5. Repeat Procedure 4 using a small amount of a mixture of equal parts of potassium chlorate and manganese dioxide.
6. Observe the demonstration on the electrolysis of water.

Name______________________________

Science IIA
Exercise

Science IIA Hour ______

Date ______________________________

GENERAL TYPES OF CHEMICAL REACTIONS

COMBINATION AND DECOMPOSITION

Write balanced equations for the following reactions.

1. the oxidation of calcium

2. the heating of nickel chlorate

3. the reaction of ferric oxide and water

4. the reaction of aluminum and sulfur

5. the electrolysis of potassium iodide

6. the heating of gold oxide (Valence of gold = +3)

7. the reaction of carbon dioxide with water

8. the reaction of ammonia and water

9. the heating of lithium chlorate

10. the reaction of hydrogen and nitrogen

11. sodium oxide reacting with water

12. the heating of ammonoim hydroxide

13. the heating of silver oxide

14. the reaction of nitrogen pentoxide (N_2O_5) and water

15. the electrolysis of chromic chloride

III. Neutralization

A. Definition

B. General Equation

C. Examples

D. Other types of Exchange Reactions

Exercise

Name ______________________

Science IIA Hour ____

Date ______________________

NEUTRALIZATION - EXCHANGE REACTIONS

Write balanced equations for the following reactions:

1. nickel sulfate reacting with hydrochloric acid:

2. the action of potassium nitrate with ammonium chloride:

3. copper chloride reacting with sulfuric acid:

4. the reaction of aluminum hydroxide and nitric acid:

5. the reaction of calcium hydroxide with nitric acid:

6. magnesium hydroxide reacting with phosphoric acid (H_3PO_4):

7. aluminum chlorate reacting with sodium sulfite:

8. lead sulfide reacting with acetic acid ($HC_2H_3O_2$) :

9. the reaction of lithium hydroxide and sulfuric acid:

10. the action of chromium nitrate and hydrochloric acid:

COMBINATION, DECOMPOSITION, AND NEUTRALIZATION

QUESTIONS FOR CONSIDERATION:

1. The gas oxygen is one of the products always formed as a result of two different decompositions. Name the two general types of compounds which can be heated to give oxygen.

2. What general type of substance, if combined with oxygen in a composition reaction will always produce a basic anhydride?

3. What general type of substance can form a base if water is added to it in a composition reaction?

4. What general type of substance can form a base if water is added to it in a replacement reaction?

5. What products are always formed in an exchange reaction involving an acid and a base?

6. If an acid and a base react in an exchange reaction will the reaction always be a neutralization reaction? Does this mean that the resulting solution will be neutral? Explain your answer.

Review Exercise

Name ______________________________

Science IIA Hour _____

Date __________________________

INTERACTIONS INVOLVING CHEMICAL CHANGE

1. Describe the type of bonds found in ionic compounds.

2. What effect does water have on ionic compounds?

3. What difference exists between the bonds in ionic compounds and those in covalent compounds?

4. What is a polar covalent bond?

5. If the water molecule ionizes into H^+ and OH^- ions why did distilled water not light the bulb in the conductance apparatus?

6. When solid NaCl is placed in the conductance apparatus it will not conduct, but a NaCl solution will. Explain.

7. Write the ionization or dissociation equations for the following substances:

   a. aluminum hydroxide

   b. ammonium hydroxide

   c. nitric acid

   d. hydrogen sulfide (a weak acid)

   e. barium sulfate

   f. lead nitride

   g. water

   h. hydrogen chromate (a strong acid)

8. What change occurs in the probable formula for water as it changes from a gas at 100°C to ice at 0°C.?

9. Describe the seven unusual physical properties of water and the reasons for these unusual properties.

10. Complete and balance the following equations:

    a. the reaction of potassium on water -

    b. the reaction of hydrated cupric sulfate on heating -

    c. the reaction of potassium oxide and water -

    d. the reaction of sulfur trioxide and water -

11. Write a neutralization equation in its simplest form.

12. Substance A has a pH of 5 and substance B has a pH of 3. Which substance has the greatest hydrogen ion concentration?

13. What is meant by "dynamic physical equilibrium"?

14. Write balanced equations for the following:

    a. the reaction of calcium hydroxide with hydrochloric acid:

    b. the reaction of zinc sulfate with nitric acid:

INTERACTIONS INVOLVING PHYSICAL CHANGE

I. Diffusion

A. Definition

B. The Mechanism of Diffusion

C. Factors Which Affect Diffusion Rates

D. The Importance of Diffusion in Living Organisms

The laboratory Investigation on pages 92-93 may be found

TITLE Investigations of Cells and Organisms

AUTHOR Peter Abramoff Robert G. Thomson

PUBLISHER Prentice Hall

PAGE NO. 36-38

Laboratory Investigation

Name ______________________

Science IIA Hour ___

Date ______________________

WHAT FACTORS AFFECT THE RATE OF DIFFUSION?

I. Data:

A. time of filling the wells: ______ : ______
(hour) (minute)

B. time of precipitate formation between wells:

wells involved	Final time	Δt *
$AgNO_3$ and NaCl		
$AgNO_3$ and $K_3Fe(CN)_6$		
$AgNO_3$ and KBr		

(* Δt = final time minus filling time)

C. distances traveled by ions before interaction resulted in precipitate formation:

points	well-to-ppt. distance in min.
from $AgNO_3$ well to $AgNO_3$ - NaCl ppt.	______
from NaCl well to $AgNO_3$ - NaCl ppt.	______
from $AgNO_3$ well to $AgNO_3$ - $K_3Fe(CN)_6$ ppt.	______
from $K_3Fe(CN)_6$ well to $AgNO_3$ - $K_3Fe(CN)_6$ ppt.	______
from $AgNO_3$ well to $AgNO_3$ - KBr ppt.	______
from KBr well to $AgNO_3$ - KBr ppt.	______

II. Analysis:

1. Any interaction that you discover between the wells will be due to an exchange reaction in which an insoluble precipitate is formed. Soluble substances remain in solution and do not form precipitates.

With the aid of the chart of water-soluble and water-insoluble compounds appearing on the right, attempt to write a balanced exchange reaction for each interaction you discover between the wells. Indicate the insoluble precipitate with a downward arrow (↓).

SOLUBLE	INSOLUBLE
$AgNO_3$	$AgCl$
$K\ NO_3$	$AgBr$
$Na\ NO_3$	$Ag_3Fe(CN)_6$
KCl	
KBr	
$K_3Fe(CN)_6$	
$NaCl$	
$NaBr$	
$Na_3Fe(CN)_6$	

$Ag\ NO_3 + NaCl$

$Ag\ NO_3 + KBr$

$AgNO_3 + K_3Fe(CN)_6$

2. Diffusion velocity (rate) is defined as change in distance per change in time ($\Delta s/\Delta t$). From the data you have collected in part I, calculate the velocities of:

Ag^+ , Cl^- , Br^- , and $Fe(CN)_6^{\equiv}$ ions and enter them in the table below:

Ion	formula weight	velocity (mm/minute)
Ag^+	108	
Cl^-	35	
Br^-	80	
$Fe(CN)_6^{\equiv}$	212	

3. On graph paper, plot diffusion velocity against formula weight (given in the table of #2).

From your curve, what can you conclude about the relationship of an ion's diffusion velocity to its formula weight?

4. In what ways are living things dependent upon diffusion?

5. Give an example of:

   a. a gas diffusing in a gas

   b. a liquid diffusing in a solid

   c. a liquid diffusing in a liquid

6. What role does Brownian movement play in diffusion (if any)?

7. As an option for extra credit, design and carry out experiments to measure the effect of concentration and temperature on diffusion rates. Plan to do this singly or as a team, in consultation with your small-group instructor.

II. Crystallization

A. Definition

B. The Mechanism of Crystal Formation

1. the binding forces

2. type of lattice structures

    a. ionic crystals

    b. covalent crystals

    c. metallic crystals

    d. molecular crystals

C. Importance of Crystallization

1. Purification of chemical substances

2. Separation of two different solutes from a solution

3. Problems associated the crystalization of solutes

D. Water of Hydration

III. Coagulation

A. Definition

B. The Mechanism of Coagulation

C. Factors which affect Coagulation

D. The importance of Coagulation

1. the formation of precipitates

2. in living matter

RATES OF CHEMICAL REACTIONS

Recommended Reading:	Chemistry, by Choppin, Jaffe, Summerlin and Jackson Chapter 14: "Chemical Kinetics" pp 292-307
	Chemistry: An Experimental Science (Chemical Education Material Study) Chapter 8, "The Rates of Chemical Reactions," pp 124-140

I. Chemical Kinetics: The Study of Rates of Chemical Reactions

A. Basic Questions concerning energy-release by chemical reactions

1. How much energy will be released by a chemical system?

2. How can we tell whether or not change has occurred or is occurring in a chemical system?

3. How long will it take for a given chemical reaction to be completed?

a. What is meant by rate?

b. How fast do reactions occur?

4. How can the rate of a particular reaction be controlled?

a. Are there reactions we would like to speed up?

b. Are there reactions we would like to slow down?

B. Common Tools Used for Measuring Reaction Rates

1. One characteristic that is basic to all techniques for measuring rates of change.

2. Common techniques for measuring rates of change (demonstration)

    a. sampling and analysis of concentrations of one of the reactants or products at various time intervals

    b. measuring and correlating a change in some physical property with a change in concentration of one of the reactants or products.

        1) changes in color intensity or quality as products with different light-reflecting or absorbing properties are formed

2) Changes in viscosity of the reaction mixture as polymers are broken into smaller molecules

3) Changes in pressure of a gaseous mixture as a solid or liquid product is formed

4) Changes in volume or concentration of some product that is easily collected or removed from the reaction mixture.

RATES OF CHEMICAL REACTIONS, Cont.

II. Factors Affecting Reaction Rates

  A. The Nature of the Reactants

    1. Some examples: (demonstration)

      a. reaction rates of metals with hydrochloric acid:

      the activity series:

      b. rates of exchange-reactions the result in the formation of insoluble precipitates

      c. comparative rates of reaction of Fe^{++} and $C_2O_5^{=}$ with $Mn\ O_4^-$

      d. comparative rates of reaction of a system composed of few ions (Fe^{++} and Ce^{++++}) and a system composed of many ions (5 Fe^{++} , $8H^+$, and 1 MnO_4^-)

2. Some general rules governing the relative rates of reaction in chemical systems:
    a. reactions not involving bond-rearrangements:
    b. reactions in which bonds are broken:

B. Factors That Affect the Frequency of Collisions Between Particles

1. The collision theory
    a. an assumption based upon the kinetic-molecular theory
    b. collision theory defined
    c. examples

2. Factors relating to the collision theory

a. The Effect of Surface Area

b. The Effect of the Type of Reaction Mechanism

1) how many steps are there to a chemical reaction?

2) problems of assuming a single step

3) new assumption based upon collision frequency and probability of collisions

4) in what order do the steps occur?

Reaction mechanisms defined

5) which step determines the rate of the overall reaction?

a) finding the rate-determining step

b) a step consists of no more than two particles interacting at a time

c) some analogies

c. The Effect of Concentration

1) what determines the frequency of interaction of one particle with another?

2) a law for finding the rate of reaction between two particles in the same reaction mixture

3) the reaction mechanism and the rate law

a) what is the rate law for the following theor t reaction?

$$A + 2B \rightarrow C + D$$

answer:

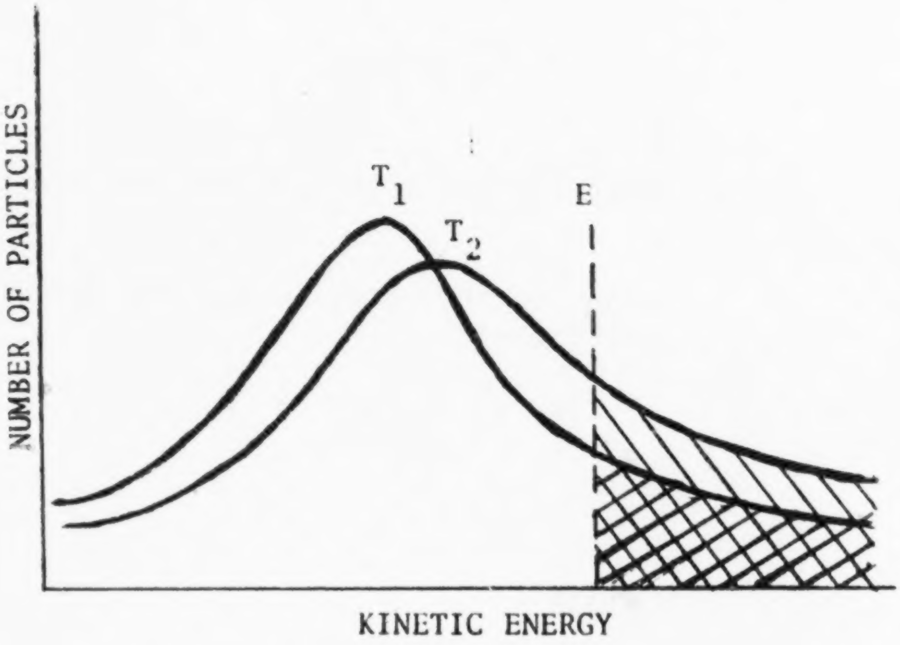
b) assuming the following mechanisms for the above reaction, what is the rate law?

1st: $A + B \rightarrow AB$

2nd: $AB + B \rightarrow C + D$

Net: $A + 2B \rightarrow C + D$

answer:



EFFECT OF A TEMPERATURE INCREASE ON THE KINETIC ENERGY DISTRIBUTION FOR A GIVEN POPULATION OF PARTICLES (molecules, atoms or ions)

d. The Effect of Temperature

1) why does raising the temperature speed up chemical reactions?

2) threshold energy defined

3) the effects of a temperature increase on a chemical system:

   a) effect on the kinetic-energy distribution for a population of particles within the system (see diagram below)

   b) effect on the frequency of collisions between different particles

111

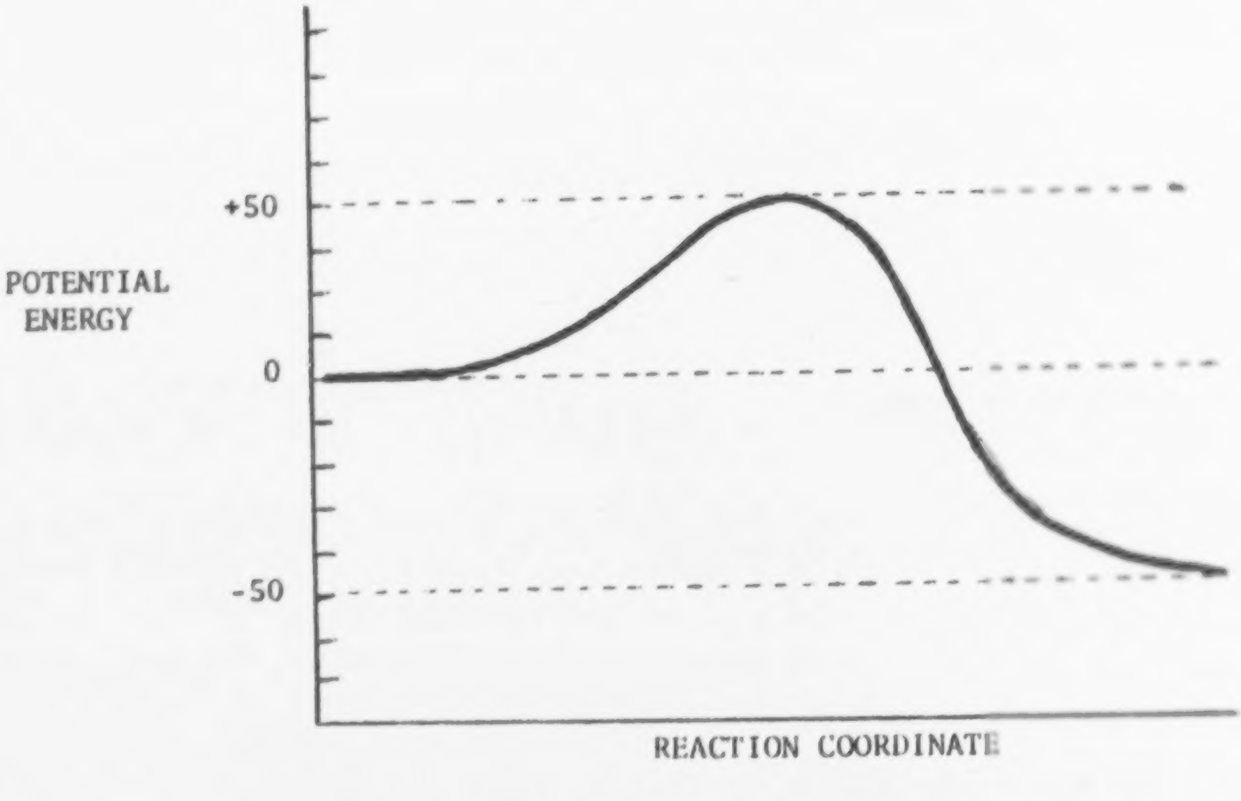
e. The Effect of Pressure

1) the ideal gas law

2) an expression for P_1 the pressure

3) the effect of a pressure-increase upon the concentration of particles within a system:

POTENTIAL ENERGY DIAGRAM FOR THE THEORETICAL REACTION $A + B \longrightarrow C + D$



RATES OF CHEMICAL REACTIONS, Cont.

III. The Opposite Roles of Energy Barriers and Catalysts in Determining Reaction Rates

A. overcoming the Energy-barrier:

1. an explanation of the potential energy diagram (shown below) for the following theoretical reaction:

$$\underset{\text{Reactants}}{A + B} \longrightarrow \underset{\text{Activated Complex}}{AB} \longrightarrow \underset{\text{Products}}{C + D}$$

2. activation energy

3. the mysterious nature of the activated complex:

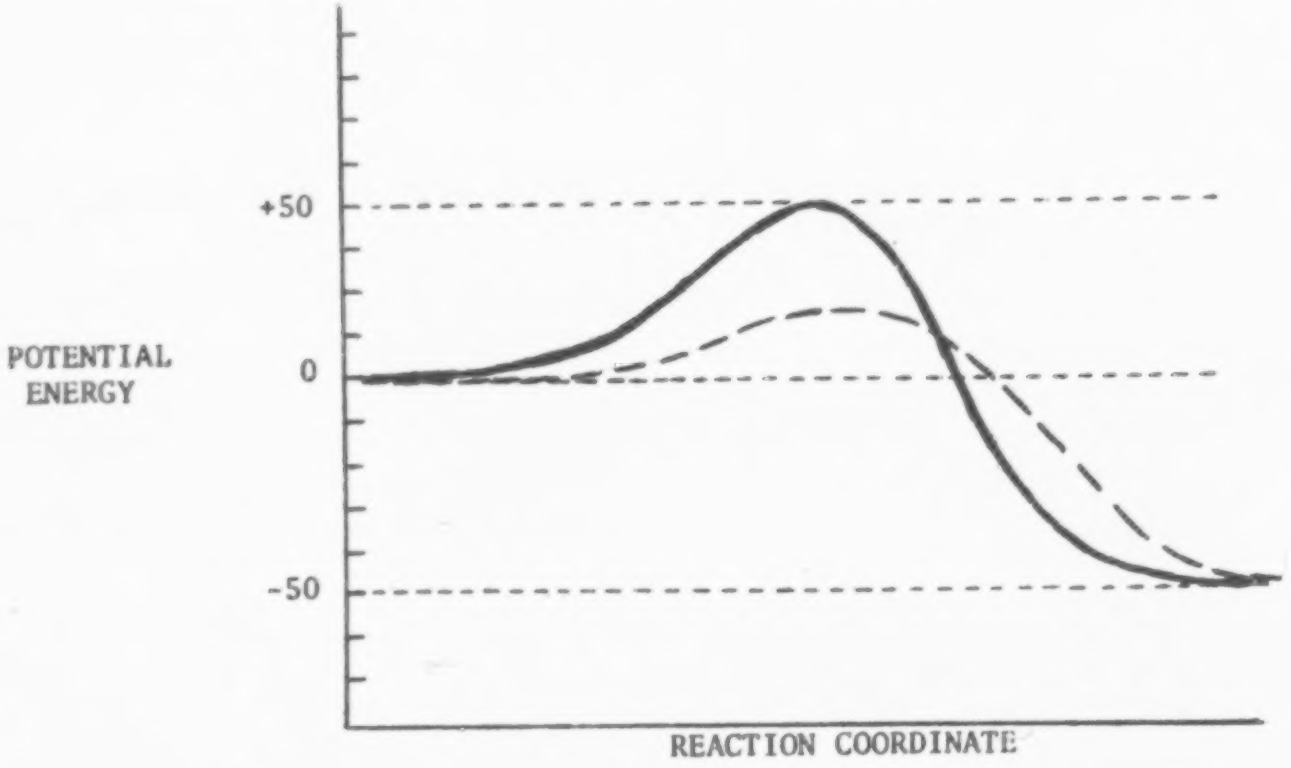
[illegible] The mysterious action of catalysts:

1. catalysis defined

2. how a catalyst works; an explanation of the potential energy diagram that shows the effect of a catalyst on the rate of a reaction:

CATALYST + REACTANT ⟶ ACTIVATED COMPLEX ⟶ CATALYST + PRODUCT

POTENTIAL ENERGY DIAGRAM SHOWING THE EFFECT OF A CATALYST



3. types of catalysts:

   a. inorganic:

   b. organic:

      1) organic catalysts are called enzymes:

$$E + S \longrightarrow ES \longrightarrow E + P$$

      2) the surprising effect of temperature on the activity of enzymes

SOME FACTORS GOVERNING THE RATES OF CHEMICAL REACTION

INTRODUCTION:

In this investigation, we will study how changes in temperature and changes in the concentration of one of the reacting substances affect the rate of a chemical reaction. The reaction that will be employed will be the catalyzed decomposition of hydrogen peroxide (H_2O_2) to form oxygen and water.

Because it is so unstable, hydrogen peroxide in a concentrated form is highly dangerous. We will be using solutions that are 3% and weaker, which are quite safe. Surprisingly, hydrogen peroxide is continually formed in every living cell, but because it is destroyed so quickly by the action of an organic catalyst called catalase, it never accumulates enough to cause any harm.

Hydrogen peroxide is also used as an oxidizer in military rockets and in the small maneuvering rockets on NASA space vehicles. It is, therefore, quite practical for space scientists to know how its decomposition-rate can be controlled.

Each experiment we perform will be run with two different catalysts: one is manganese dioxide, an inorganic catalyst, the other is catalase, an enzyme found in every living cell. We will use concentrated liver-juice which is very rich in catalase. The purpose of using two different catalysts is to determine whether or not their behaviors differ as we vary the temperature or the hydrogen peroxide concentration.

PURPOSE:

To discover how varying the temperature of the reaction mixture or the concentration of hydrogen peroxide can affect the rate of decomposition of hydrogen peroxide to oxygen and water.

To investigate and compare the effects of an inorganic catalyst (MnO_2) and an organic catalyst (catalase) on the rate of the reaction and to see what effect varying the temperature or the H_2O_2-concentration might have on their activity.

MATERIALS: (per team of two students)

50 ml flask
stopper with funnel and right-angle bend
delivery-tube with right-angle bend at one end
water-trough or large beaker (800-1000 ml)
gas-burette, burette-clamp and ring-stand
aluminum foil
forceps
1 ml pipette
10 ml graduated-cylinder
tripod, gauze, beaker, and burner for constant-temperature bath
thermometer
H_2O_2 (1% strength) MnO_2 concentrated liver-juice (source of catalase)

PROCEDURE:

I. Following the Progress of Reaction from Start to Completion at 22°C

Working in pairs, set up your flask-generator and gas-collecting apparatus as shown in the figure on the facing-page. Attend to each of the following items:

a. The gas-burette must be completely filled with water, inverted into the trough, and clamped in place so that its mouth is well below the surface of the water in the trough.

b. Place exactly 20 ml of 1% H_2O_2 solution into the 50 ml flask.

c. Make a small water-tight boat out of aluminum foil and carefully place one of the following materials into it as assigned by your instructor:

   1) 1 gram of MnO_2 powder

   2) 1 ml of concentrated liver-juice

d. With a forceps, carefully lower the boat into the flask and float it on the H_2O_2 surface. Do not allow any of the contents of the boat to spill over into the H_2O_2. Even a trace will start the reaction.

e. Stopper the flask without disturbing the boat and its contents. The end of the funnel-stem should be below the H_2O_2-surface and the stopper should be tight (see figure).

f. Connect the delivery-hose to the right-angle bend already in the stopper and insert the free end of the tube (also with a right-angle bend) into the water-filled trough or 800 ml beaker.

g. The free end of the hose should be inserted into the gas-burette so that it is held there by the right-angle bend (see figure). In this position, none of the gas produced by the reaction will be able to escape.

h. Before starting the reaction between the catalyst and the hydrogen peroxide, decide on one partner to take the responsibility for calling start, calling out the time in 15 sec. intervals, and for recording the data (ml of O_2 formed) on the data sheet.
The other partner is to start the reaction at the instant that the starting time is called, and report the ml of O_2 at each time-interval, continuing to report until O_2 production ceases.

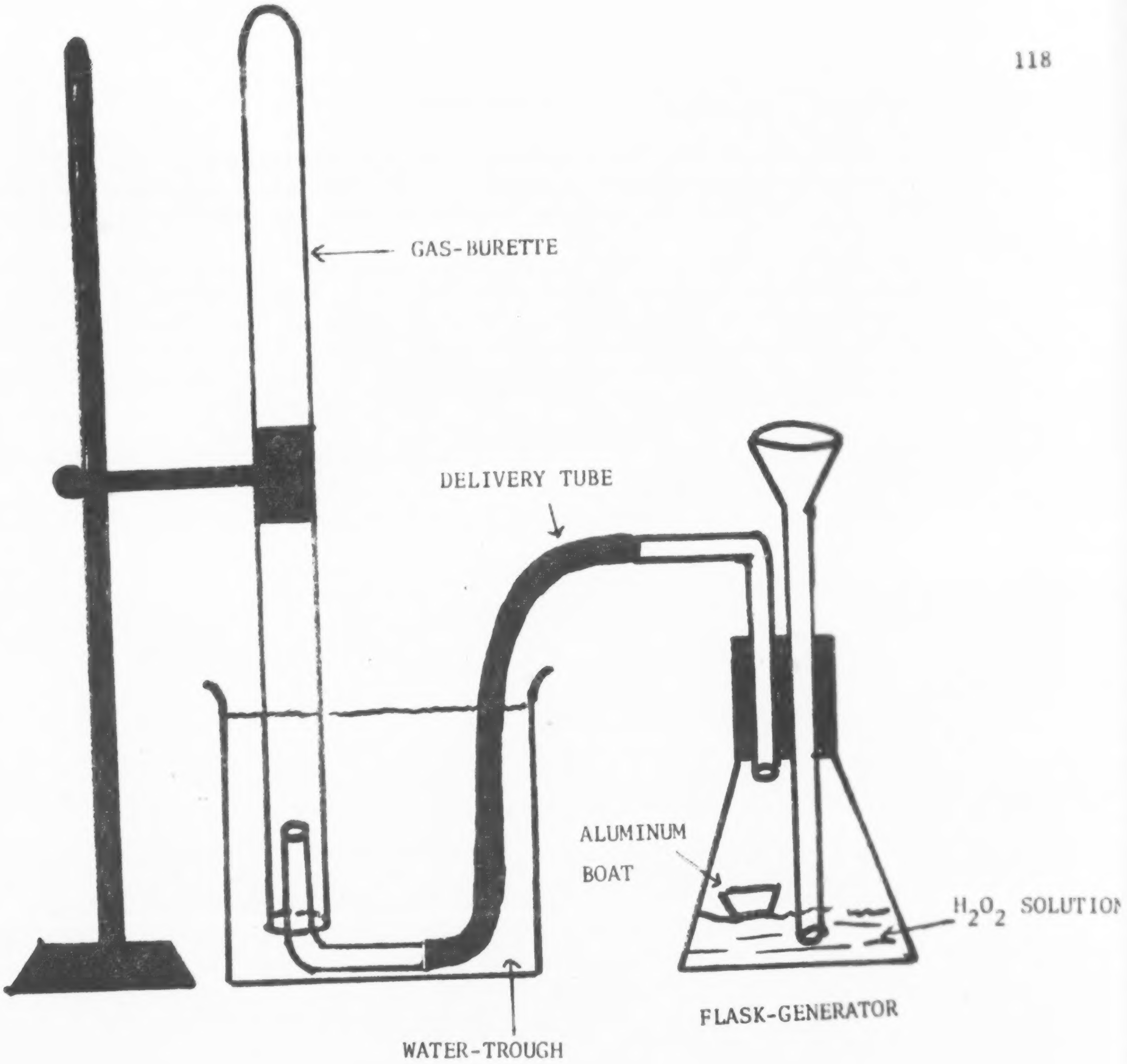
i. To start the reaction, merely shake the flask so as to sink the boat, mixing its contents with the H_2O_2-solution. This must be done the moment the timer-data keeper calls start.

j. After the completion of the reaction, clean out the reaction flask and tubes, rinse well with distilled water, and get ready to go on to Part II.

II. Effect of H_2O_2 Concentration on Reaction Rate at 22°C.

In this part of the investigation, the reaction is to be run under the same conditions as it was in Part I, but this time each time will be assigned a different concentration of H_2O_2 by the instructor. Concentrations will vary from 0.01% to 1%, using 20 ml volumes as in Part I.

The only data to be taken will be the time required for the reaction to form the first 10 ml of oxygen gas. (That is, the Δt from start to the time when the gas-burette reads 10 ml.)
Perform the experiment twice: once with MnO_2 as a catalyst, and once with catalase.


GAS-BURETTE
DELIVERY TUBE
ALUMINUM BOAT
H_2O_2 SOLUTIO
WATER-TROUGH
FLASK-GENERATOR

III. Effect of Temperature on Reaction-Rate

In this part of the investigation, the H_2O_2 concentration will be 1%, but this time the temperature will be varied. At the temperature assigned to you, run the experiment twice, once with MnO_2 and once with catalase.

To establish the desired temperature, place the flask-generator and its contents in a constant-temperature bath that is maintained by heating with a bunsen burner or by cooling with cold-water or ice. Once the temperature of the bath is properly adjusted, place the flask and contents in the bath and allow it to remain there for at least 10 minutes in order to reach the same temperature as the bath. Then start the reaction.

Data to be collected is the time required for the reaction to form the first 10 ml of oxygen gas

Lab Investigation

Data and Analysis Sheet

Name ________________________________

Science IIA   Hour _____

Date ________________________________

SOME FACTORS GOVERNING THE RATES OF CHEMICAL REACTION

I. Following the Progress of Reaction from Start to Completion at 22°C

A. Data

MnO_2 (1 gram)		Concentrated Liver Juice (1 ml)	
time in sec.	ml. of O_2	time in sec.	ml of O_2

B. Analysis.

1. Write a balance equation for the reaction.

2. Assuming the H_2O_2 to be completely broken down into O_2 and H_2O, how many moles of the H_2O_2 were converted to O_2 and H_2O in the first minute?

3. On graph paper, plot ml. of O_2 formed vs. time.

4. According to the curve obtained in #3, is the rate of O_2- formation constant throughout the experiment? Why?

5. What would the curve look like if the rate of O_2- formation were constant throughout the reaction?

6. a) How does the rate of O_2- formation relate to the rate of reaction?

   b) What is happening to the rate of O_2 formation as the reaction progresses? Why?

7. a) From the graph, how can the rate of O_2 formation in ml per minute be determined for any given time interval?

b) Determine the average rate of O_2 - formation in ml per minute during each of the following time-intervals on your graph:

1) 0 and 15 seconds
2) 60 and 75 seconds
3) 120 and 135 seconds
4) 240 sec and 255 seconds
5) 1200 seconds and 1215 seconds (make a prediction)

c) During which time-interval is the rate of O_2 - formation the fastest?

d) When will the rate of O_2 - formation be zero? Why? What will the curve do when this point is reached?

II. Effect of H_2O_2-Concentration on Reaction Rate at 22°C.

A. Data:

MnO_2 (1 g)				Conc. liver juice (1 ml)			
H_2O_2 conc	t_0	t for 10 ml	Δt	H_2O_2 conc	t_0	t for 10 ml	Δt
1.00%							
0.75%							
0.50%							
0.10%							
0.01%							

B. Analysis:

1. From the data, plot the time required to form the 1st 10 ml. of oxygen against the H_2O_2-concentration.

2. What generalizations can you make concerning the effect of varying the concentration-on the time required for the reaction to form the 1st 10 ml. of O_2?

3. How is the time of the reaction related to the rate of the reaction?

III. Effect of Temperature on Reaction Rate

A. Data:

MnO_2 (1 g)				A Conc. Liver Juice (1 ml)			
temps	t_0	t for 10 ml	Δt	temps	t_0	t for 10 ml	Δt
0°C							
10°C							
22°C							
37°C							
60°C							
80°C							
90°C							

B. Analysis:

1. Plot a graph of time of formation of 1st 10 ml of O_2 versus temperature.

2. What general relationships between reaction-time and temperature; and reaction-time and rate can you derive from your graph?

3. Predict the time of reaction at 100°C, assuming that the other variables in the experiment are kept constant.

4. Plot various functions of time versus temperature in search of a linear relation.

5. Is the effect of temperature on reaction-rate the same for both catalysts?
Describe an hypothesis to explain the rather unexpected effect of temperature on the activity of catalase.

Assignment

Name ______________________________

Science IIA Hour ____

Date ______________________________

RATES OF CHEMICAL REACTIONS

1. Do any five of the following:

In what units would you express the rate of:

__________ a. movement of a rocket in space

__________ b. rotation of a record on a turntable

__________ c. gain in altitude

__________ d. conversion of reactants to products during a chemical reaction

__________ e. fish killed by pollution

__________ f. forestland destroyed by highway construction

__________ g. production of automobiles by an assembly plant

__________ h. consumption of water by a family

__________ i. decay of a radioactive element

2. Circle the member of each pair that has the greater reaction rate. Assume that each member of a pair is subjected to the same conditions:

   a. iron rusting or copper tarnishing

   b. wax burning or paper burning

   c. evaporation of alcohol or evaporation of water

   d. decomposition of protein or decomposition of cellulose in a dead plant.

3. Do either a or b:

__________ a. The concentration of a reactant changes from 0.05 to 0.025 moles in 30 minutes. Give an expression for the average reaction rate during this interval.

__________ b. The amount of a liquid product formed and collected during a certain decomposition reaction changes from 5ml to 25ml in 5 minutes. Give an expression for the average reaction rate during this interval.

4. Explain one of the following phenomena in kinetic-molecular terms:

   a. Why an increase in the concentration of a reactant may cause an increase in the rate of reaction.

   b. Why a lump of coal burns slowly, but the same amount of coal as dust, explodes in air.

   c. Why cooling an enclosed sample of steam causes it to condense into a liquid.

5. Consider two gases A and B in a container at room temperature. What effect will each of the following changes have on the rate of reaction between these gases?

__________ a. doubling the pressure

__________ b. doubling the number of molecules of gas A.

__________ c. increasing the temperature while maintaining constant volume.

6. State three methods by which the pressure of a gaseous system may be increased.

____

____

____

7. An increase in temperature of 10°C rarely doubles the kinetic energy of particles and hence the number of collisions is not doubled. Yet, this temperature increase may be enough to double the rate of a slow reaction. How can this be explained?

8. In the potential energy diagram on page 112 why is kinetic energy decreasing as A and B go up the left side of the barrier and why is kinetic energy increasing as C and D go down on the right side? Explain in terms of conservation if energy and also in terms of what is occurring to the various particles in relation to each other.

9. Imagine five people working together to wash a stack of very greasy dishes. The first two clear the table and hand the dishes to the third person who washes them and hands them on. The last two persons dry and stack them.

____________ a. Which step is likely to be the rate-determining step?

b. In light of your answer, discuss how the overall process would be affected if a sixth person joined the group as a

1) table clearer

2) 2nd dish-washer

3) dish dryer

10. a. What is the rate law for the following reaction?

$$H_2 + Cl_2 \qquad 2\ HCl$$

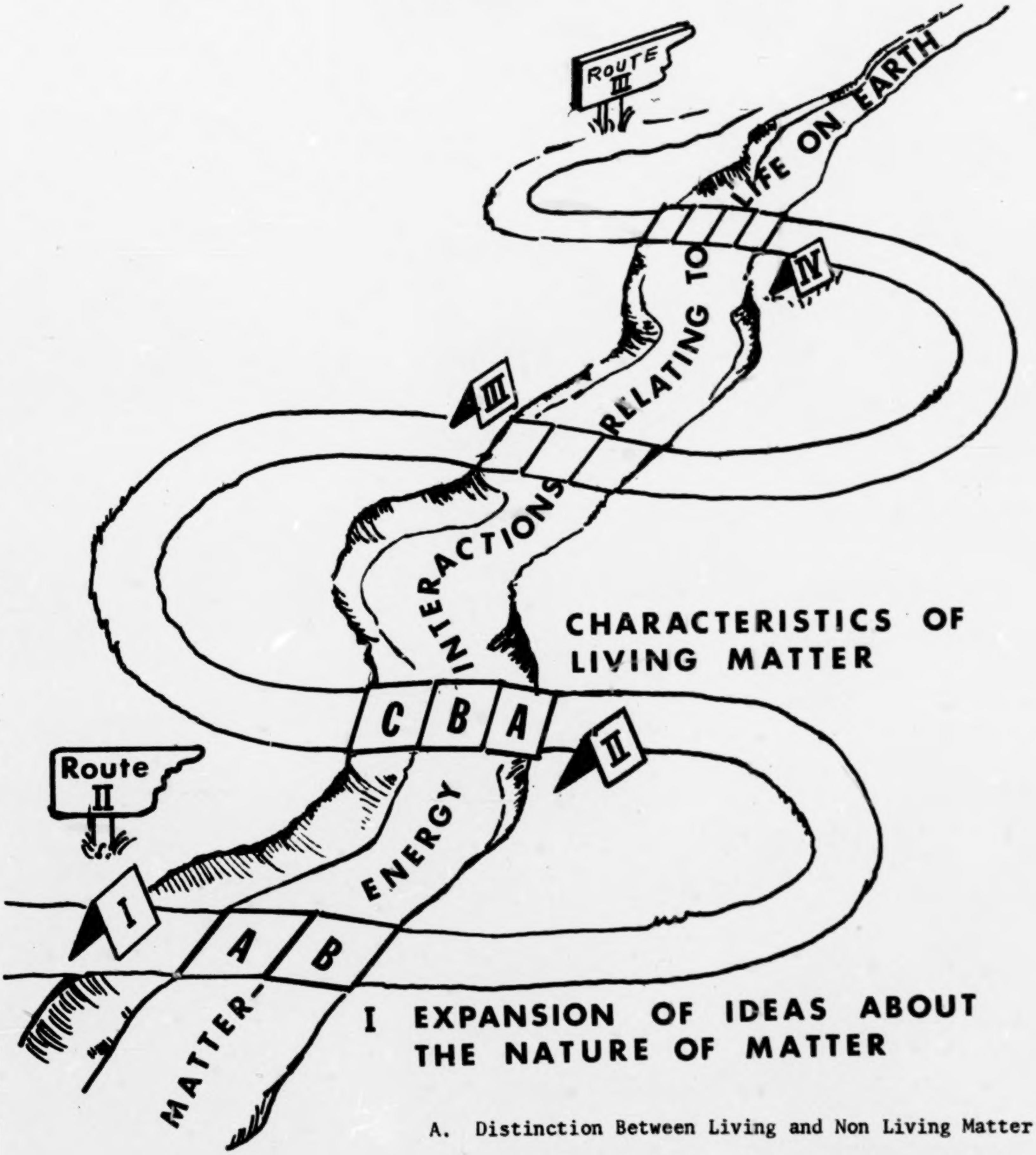
b. Propose a possible mechanism for the above reaction, giving its rate law:

c. Why is it impossible for you to be absolutely certain that your reaction mechanism is correct?

11. Use the terms activation energy, activated complex, and reaction mechanism to describe the effect of adding a catalyst to a normally slow reaction rate to obtain a faster rate.

12. Why do you think it took so many years to discover activated complexes in catalyzed reactions?

SCIENCE IIA


ROUTE III
MATTER-ENERGY INTERACTIONS RELATING TO LIFE ON EARTH
IV
III
CHARACTERISTICS OF LIVING MATTER
C
B
A
II
Route II
I
A
B
I EXPANSION OF IDEAS ABOUT THE NATURE OF MATTER

A. Distinction Between Living and Non Living Matter

B. The Diversity of Living Things

C. Fundamental Life Processes

Distinction Between Living and Non-Living Matter

HISTORICAL DEVELOPMENT OF THE CONCEPT OF LIFE

Required Reading:	BSCS Yellow Version, Chapter 2, "Life From Life".
Recommended Reading:	"*The Dawn of Life*," J. H. Rush, pp 94-112.
Recommended Film Strip:	"Origins of Living Things"

I. Theories on the Origin of Life

- A. The Theory of Special Creation -
  1. "Genesis"
  2. No Scientific Evidence to Prove or Disprove
- B. The Theory of Spontaneous Generation
  1. Ideas from Antiquity -
  2. Jan Baptista van Helmont, Flemmish physician and alchemist, 1577-1644.
  3. Francisco Redi, Italian physician and poet, 1626-1697

4. Anton van Leeuwenhoek (lay´- ven - hook), Dutch biologist and microscopist, 1632-1723.

5. John Turberville Needham, English naturalist, 1713-1781

6. Lazzaro Spallanzani - Italian biologist, 1729-1799

7. Louis Pasteur, French chemist, 1822-1895

C. The Cosmozoic Theory

1. Svante August Arrhenius, Swedish chemist, 1859-1927

2. Worlds in the Making, published 1908

3. Two problems with the Cosmozoic Theory

D. The Theory of Organic Evolution

1. Definition of Organic Evolution

2. Conditions Required on the Earth for Organic Evolution

3. Experimental Evidence

    a. A. I. Oparin - Russian chemist

    b. Stanley Miller - American chemist, 1930

    c. Sidney Fox - American chemist

    d. Carl Sagan, American astronomer, 1934-

A Reading

TRACING THE ORIGIN OF LIFE

Source: The American Biology Teacher, October, 1961)

The origin and development of life on our planet are questions of paramount importance, the study of which has a direct bearing on our understanding of the world we live in and of its history.

In our endeavor to explain the origin of life we may rely on the comprehensive scientific hypothesis of Academician A. I. Oparin which in its biochemical part merits recognition as a theory.

But up until recently we were unable to trace the "roots of life". Paleontology has accumulated a wealth of materials on the development of life but only to a period of not more than 570 million years. "The roots of life" certainly go much deeper. For 570 million years ago life in the seas was already represented by many groups of comparatively highly developed animals and plants - worms, crustaceans, multi-cell red and blue-green algae. But where the sources of life lie remains a mystery.

Several sciences, such as geology, geochemistry, and stratigraphy, have had to attain a high level of development to help paleontology delve into more ancient times. Thanks to the joint efforts of geologists, petrographers, geochemists, and stratigraphers it was established that the earth crust with its oceans formed 3,500 to 4,600 million years ago. Since the evolution of life on earth proceeded ever faster as time went by, there is every reason to believe that life originated very much earlier than is assumed. But when?

Modern microscopy makes it possible to establish that very fine preparations from ancient sedimentary rocks contain quite a few remnants of bacteria and some doubtful formations which could be living organisms - possibly plants.

The primary atmosphere and hydrosphere differed strongly from what they are today. Most likely they contained methane, ammonia, and free hydrogen, while oxygen and nitrogen were probably absent. The atmosphere contained also much water vapor, carbon dioxide, sulfur dioxide, chlorine, helium, and argon. It was probably much thicker than now. According to the latest findings of microbiologists, bacteria could well sustain in the primary atmosphere and take an active part in the formation of rocks.

There are groups of bacteria capable of surviving only on hydrogen and some simple carbon compounds. Some groups of bacteria can thrive on the decomposition of hydrocarbon gases. Some microorganisms are able to live thanks to the energy released by the transformation of ammonia, sulfur, iron, etc.

The successes of modern paleontology enable us to consider that such anaerobic bacteria appeared 3,500 to 4,600 million years ago, i.e., soon after the formation of the earth crust. Furthermore, these microorganisms changed the composition of the atmosphere, but not only the atmosphere, paving the way, as it were, for the future blossoming out of life.

The last proposition needs to be explained. There exist bacteria capable of splitting up sulfates (gypsum, for instance), with the subsequent formation of hydrogen sulfide. After this, sulfur was reduced from this hydrogen sulfide. In this way many deposits of this element formed at various geological periods.

Some bacteria precipitate limy silt which later on went on to form limes, marbles, dolomites, marls, and some other sedimentary rocks.

Academician V. I. Vernadsky was the first to express the supposition that nitrogen and oxygen are secondary biogenic gases. They appeared in the atmosphere thanks to the activity of certain groups of microorganisms. By decomposing primary compounds these bacteria satiated the air with nitrogen. Nitrogen compounds provided these bacteria with the energy needed for their life.

As for oxygen of the atmosphere, it was created not so much by bacteria as by algae which filled the atmosphere with oxygen in the process of breaking up carbon dioxide with the help of sunlight.

Only after microorganisms and algae had done the job of creating a suitable atmosphere did it become possible for life to start developing vigorously. Thus, it was microbes and algae that were the "sculptors" of our planet.

It is beyond doubt now that bacterial life existed on earth as early or more than 3,000 million years ago. Algae appeared a little later on; their oldest remnants date back 1,500 to 2,000-odd million years ago. Some carbonate rocks of this age have retained traces of fine cellular structure. The deciphering of these structures has even made it possible to single out species, genera, and families of blue-green and red algae. The number of these organisms is amazing. In this connection it should be stressed that giant accumulations of red and blue-green algae in primeval seas were their own killers. Paradoxically, but that was so. The algae changed the environment of habitation. These changes stimulated the development of some forms of organisms while resulting in the destruction of those failing to adapt themselves to the new environment.

But even now much of what is connected with the dawn of life on earth remains unknown. Much effort still has to be done to trace the history of life hidden beyond the vistas of time.

Small Group Investigation

RANDOM SYNTHESIS

A significant part of scientific research is done after the experimental data have been recorded. In this exercise, data from two of the experiments Miller, Urey, and Fox are described. The job of interpreting the data is up to you.

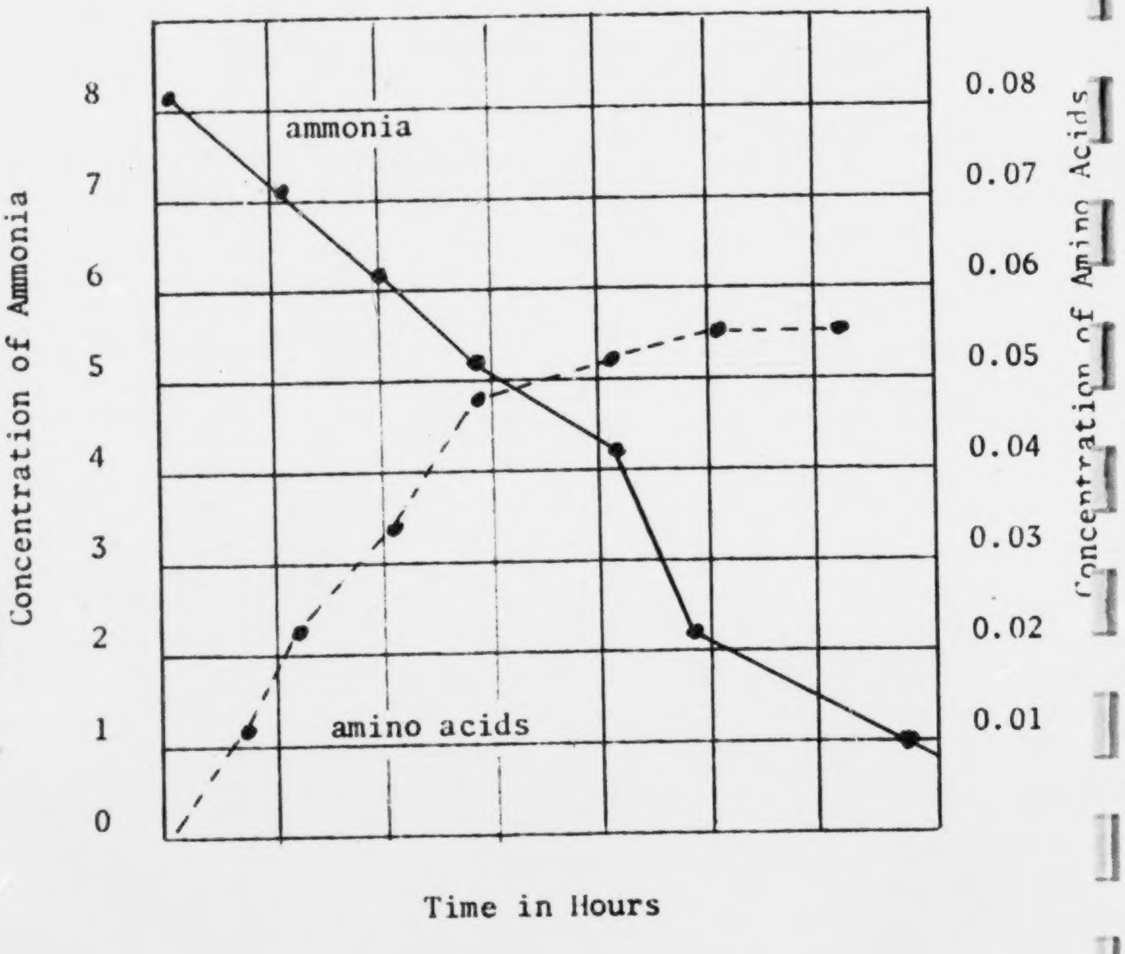
The Formation of Amino Acids

In 1953 Miller and Urey reported the successful production of amino acids from an atmosphere of ammonia, methane, hydrogen, and water exposed to an electrical discharge. The graph summarized some of the experimental data obtained by Miller. The horizontal axis shows the time elapsed from the start of the experiment, while the vertical axis shows the concentration (relative amount) of two of the substances shown. Remember, however, that other materials (methane, hydrogen, etc.) also were present, and that the concentrations of these materials were changing along with the ammonia and amino acid concentrations.

Notice that the ammonia concentration is given in the scale on the left of the graph but the amino acid concentration is to be read from the scale on the right.

From these scales you can see that the concentration of ammonia is actually about one hundred times that of the amino acids. In effect, two graphs have been combined here to make direct comparison easier.

What would be the appearance of the amino acid curve if it had been drawn to the same scale as the ammonia concentration curve?



Graph showing the concentration of amino acids and ammonia in spark discharge apparatus during Miller's synthesis

DISCUSSION:

1. Did the amount of ammonia present increase or decrease during the experiment?

2. What change occurred in the amount of amino acid present?

3. Ammonia and amino acids both consist in part of nitrogen. How can you account for the decrease in the amount of ammonia?

4. Briefly summarize and explain the changes in concentrations that took place during the course of the experiment.

5. Methane concentration was not included on this graph. What do you suppose would be the most likely shape of a curve showing methane concentration during the experiment?

THE FORMATION OF POLYPEPTIDES

Sidney Fox used the results of Miller's experiment as the basis for further investigation. He hypothesized that temperatures on the primitive earth were quite high and that proteins might have been produced under these conditions.

Dr. Fox mixed a number of amino acids found in the proteins of all organisms. He gently heated the dry mixture of amino acids to about 90°C. After heating the mixture he found that several polypeptides, substances similar to proteins, had been formed from the amino acids. In other experiments he found that if he added polypeptides were allowed to cool. Many microscopic, spherical structures formed. These structures, which Dr. Fox called microspheres, were about the size of bacteria and were composed of proteinlike molecules. Dr. Fox observed that the microspheres shrink in salt water and swell in distilled water.

DISCUSSION:

1. What evidence is available to show that proteins could have been produced on a hot primitive earth?

2. What evidence is available to show that proteins could have been produced even if the earth were somewhat cooler?

3. What evidence is available to show that the polypeptides produced experimentally are similar to proteins found in living organisms?

4. What do you think of the following hypothesis for the origin of life? "We know now that life began when amino acids were produced from ammonia by lightning. In the next step, these amino acids fell into hot water, where they turned into proteins. Finally, the hot water cooled and the proteins became bacteria.

pp. 137-139

The material masked out on this page may be found:

Adapted from:
Title **Twenty-Six Afternoons of Biology**

Author **Wald et al.**

Publisher **Addison-Wesley Publishing Company**

Page Number **Reading, Mass, 1966 pp. 7-12**

Laboratory Report Sheet

Name ______________________

Science IIA Hour ____

Date ______________________

WHAT IS LIFE?

I. Preparation for Lab: Questions

1. Your definition of what you believe life to be:

2. Your list of characteristics or functions which a thing must possess in order to be alive.

3. Definition of life commonly agreed to by your entire class, with list of functions of living things.

II. Models for Life: Questions

A. First Specimen:

1. Describe any observations you made about the behavior of this specimen.

2. Make a series of sketches showing how this specimen moves. Using the calibrated teeth in the eyepiece which measures the diameter of the field calculate how long it would take this specimen to move 1 mm.

3. What do you believe the tiny rod shaped particles outside the specimen to be?

4. Did the specimen absorb or in any way take these tiny rod shaped particles in? Make a sketch to show this.

5. What relationship would you hypothesize to exist between specimen one and the rods?

6. Make the most detailed drawing you can of specimen one.

7. Are the parts of specimen one stationary or do they move? Describe any motion you see.

8. You may be able to see some large pinkish cavities inside specimen one. (You can see these better if you cut down the amount of light entering the iris diaphragm of your microscope.) Make a sketch of the specimen showing these cavities.

9. If you were told that the cavities observed above were filled with watery fluid what would this suggest to you about the function of these structures?

10. State whether you believe specimen one to be living or non-living. List as many reasons to support your argument as possible.

B. Second Specimen:

1. Did specimen two reject or accept the uncoated glass particle?

2. Did specimen two reject or accept shellac coated glass particle?

3. Describe any changes in specimen two's appearance upon continued feeding.
   Make a series of drawings showing appearance.

4. State whether you believe specimen two to be living or non-living.
   List as many reasons to support your statement as possible.

C. Third Specimen

1. Describe the behavior of specimen three upon the addition of potassium dichromate.

2. Does its behavior fit into the definition of life as established by the class? Does its behavior contradict this definition in in any way? Explain/

3. By what means does specimen three increase its numbers? Show the process in a series of drawings.

4. State whether you believe specimen three to be living or non-living. List as many reasons to support your statement as possible.

PROBLEMS OF DISTINGUISHING BETWEEN LIVING AND NON-LIVING MATTER

An Exercise in Preparing and Observing
Living Cells and Comparing them with Coacervates

Recommended Reading: BSCS Blue Version, pp 107-115

INTRODUCTION:

In this exercise you will have the opportunity to observe living cells from your own body and to compare these cells with a most unusual phenomenon called a coacervate. A coacervate is a grouping together of many large molecules which occurs under carefully controlled conditions of temperature and pH. A coacervate gives the appearance of being very much like a cell, but of course coacervates are not alive. However in 1924 the Russian scientist A. I. Oparin proposed that coacervates could have occured on earth under certain conditions and that they possibly could have been the precursor of living cells.

Part I. Observation of Living Cells

PROCEDURE:

Prepare a clean slide and coverslip putting a small drop of water on the slide; then take the broad edge of a toothpick and gently run it over the surface of the inside of your cheek. You will not be able to see them but there will be many cells on the toothpick. Dip the toothpick into the drop of water on the slide and stir it around. Place the coverslip on the drop and observe under low and high power.

1. Make sketches on the lab sheet provided.
2. Now stain the same slide with either crystal violet or methylene blue and observe and sketch again. Be sure to label any additional structures which the staining process revealed.
3. Make several unstained cheek cell slides and try the following procedures
   a. 1) vary temperatures by gently warming slide over a boiling water bath. Then observe under microscope.

      2) vary $[H^+]$ by adding a drop or two of 0.1N HCl or 0.1N NaOH to slide. Then observe under scope.

      3) add a drop of 3M NaCl before observing under scope.

      4) pressure can be applied semi-quantitatively by adding pennies to the top of the cover-slip. Students can determine how many pennies it takes to destroy the coacervates. They should be pretty strong!

Part II. Formation of Coacervate Droplets

This experiment involves exactly the same procedure that Oparin used in making coacervates by complexing gelatin and gum arabic. The procedure is described in Oparin's own words in his book, The Origin of Life.

PROCEDURE:

1. Each in separate test tubes, 5 ml. of gelatin and 3 ml of gum arabic solutions are warmed in a water-bath up to 42°C. This is crucial to success!
2. When the desired temperature is reached, the contents of one test tube is poured into the other to make a single solution of the two components together. This mixture is kept at 42°C. by occasional warming in the 42°C water-bath.
3. The mixture is made acidic by the dropwise addition of 0.1N HCl. One or two drops should be sufficient to turn the mixture cloudy-white with hundreds of coacervate droplets. Any excess of acid beyond the amount required to turn the mixture cloudy will result in the destruction of the droplets.

OBSERVATIONS:

A pipette has been provided to take a drop of the coacervates from the mixture to observe under the microscope.

Each time something new is tried with the coacervates, students should start with a fresh drop on a glass-slide.

Record your observations on the Lab Report Sheet.

a. 1) vary temperatures by gently warming slide over a boiling water bath. Then observe under microscope.
   2) vary $[H^+]$ by adding a drop or two of 0.1N HCl or 0.1N NaOH to slide. Then observe under scope.
   3) add a drop of 3M NaCl before observing under scope.
   4) pressure can be applied semi-quantitatively by adding pennies to the top of the cover-slip. Students can determine how many pennies it takes to destroy the coacervates. They should be pretty strong!

b. 1) make a sketch of an unstained coacervate.
   2) Iodine solution, methylene blue, and safranin are provided to demonstrate the permiability of coacervates to water and these materials. All three should stain the droplets very intensely. Stain may sometimes collect within the vacuoles of these coacervates.

Laboratory Report Sheet

Name ______________________________

Science IIA Hour ____

Date __________________________

PROBLEMS OF DISTINGUISHING BETWEEN LIVING AND NON-LIVING MATTER.

An Exercise in Preparing and Observing Living Cells and Comparing them with Coacervates

Part I. OBSERVATION OF LIVING CELLS

1. Make sketches of unstained cheek cells under low and high power, labeling any structures which may be visible.

low power

high power

2. Make sketches of stained cheek cells under low and high power, labeling any structures which may be visible.

low power

high power

3. a. What was the effect of temperature change on the cells?____________________

b. What was the effect of pH changes?____________________

c. What was the effect of adding salt?____________________

d. How much pressure could the cells withstand before being crushed?__________

e. Do not include staining - has been done above.

Part II. FORMATION OF COACERVATE DROPLETS

1. a. What is the effect of temperature changes on the coacervate? Does it hold up better or worse than the cheek cell when gently warmed?__________

b. What is the effect of pH changes on the coacervate? How does its reaction compare to the cell's reaction?____________________

c. Note the effect of 3M NaCl on the coacervate. Compare the coacervates' response to the concentrated salt with the cell's response.__________

d. How much pressure can the coacervate withstand before being crushed? How does this compare with the cell?____________________

2. a. Make a sketch of an unstained coacervate. Note any structures which might compare to cell structures.

b. Make a sketch of a stained coacervate. State which stain you used.

CONCLUSIONS:

From your experiment you may have reached some conclusions regarding the problems in distinguishing living from non-living matter.

1. In what ways are the cell and coacervate alike in structure?

____

____

____

2. In what ways are the cell and coacervate alike in their reponse to changes in their environment, i.e. pH, temperature, salt and pressure?

____

____

____

____

3. Describe any structural differences between the cell and the coacervate that you observed under the microscope.

____

____

____

____

4. Describe any difference in response between the cell and coacervate to changes in their environment.

____

____

____

QUESTIONS:

1. You knew before beginning the lab that the cell was alive and coacervate was not. Did you notice anything in your lab results which demonstrated this? If yes, explain.

2. What are the functions possessed by the cell which distinguishes it from the coacervate?

3. Can you think of any "organism" which might rest on the borderline between living and non-living things?

The Diversity of Living Things

THE NATURE OF DIVERSITY

Recommended Reading:	Hanson, Earl D., *Animal Diversity*, Chapter 2
	BSCS Yellow Version: Chapters 18, 37, 39

I. Variations according to structure and form

   A. external variation

      1. size, color, shape

      2. symmetry

      3. organization of external body parts

B. Internal Variation

1. placement of organ systems (dissections)

2. Structure of cells and chromosomes

3. structure of biochemical molecules

II. Variation According to Pattern of Behavior in Carrying Out Life Functions

A. detection of stimuli

B. movement

C. food-getting and digestion

D. courtship, nest-building, reproduction

III. Variation According to Pattern of Reproduction and Development

A. sexual and asexual reproduction

B. internal and external fertilization

C. internal and external development

D. maternal-paternal dependence or independence at birth

IV. Variations According to Type of Habitat

THE SYSTEMATICS OF PLANT AND ANIMAL DIVERSITY

Recommended Reading: Hanson, Earl D., Animal Diversity, Chapters 3 and 4

BSCS Yellow Version: Chapter 14; pp 277-277
Chapter 19; pp 348-371
Chapter 39

I. The Principles of Taxonomy

A.

B.

C.

II. Classification: A Tool for Recognizing Diversity Among Living Things

A. Diversity within the Plant Kingdom

B. Diversity within the Animal Kingdom

THE DISTRIBUTION OF LIVING THINGS IN SPACE AND TIME

Recommended Reading: Hanson, Earl D., Animal Diversity, Chapters 5, 6, 7, 8

BSCS Yellow Version, Ch. 9: pp 190-197
Ch. 13 and 14
Ch. 19: pp 371-387
Ch. 31: pp 579-585
Chs. 33, 34, 38

Neill, Wilfred T., BSCS pamphlet #18: Biogeography

Allee, W. C., The Social Life of Animals, Chs. 10, 11,

I. Diversity in Time

A. temporal diversity defined

B. sources of information concerning the temporal diversity of living things

C. predictions based upon information gained from these sources

1. the results of change

2. the direction of change

3. diversity as affected by habitat-changes

II. Diversity In Space

A. spatial diversity defined

B. sources of information concerning spatial diversity

C. questions concerning spatial diversity

1. What should we expect spatial diversity to be like?

2. What kind of diversity should we expect to see among organisms that have undergone adaptive changes?

   a.

   b.

   c.

III. Phylogeny

A. phylogeny defined

B.

IV. The On-Going Process of Diversification

A. questions concerning the destiny of endangered species

B. questions concerning the destiny of man

1. man as an endangered species

2. the nature of man's real enemies

3. the problem of social cooperation

4. the future of man: his successors?

pp. 160-162

The material masked out on this page may be found:

Title **"Drosophila Chromatography - Again"**

Author **Mettens and Bennett**

Publisher **Turtox News Sept. 1969**

Page Number **pp 220-221**

Laboratory Investigation

Name ____________________

Science IIA Hour _____

Date ____________________

Chromatographic Separation of Pterdine Compounds from Various Mutants of *Drosophila*: A Study of Biochemical Diversity

I. Data and Analysis:

A. PROPERTIES OF PTERIDINES

	Name of Pteridine	Color emitted in White Light	Color emitted in U.V. Light	R_f Value
	Drosopterin		orange	
	Biopterin		blue	
	Xanthopterin		blue-green	
	Isoxanthopterin		blue-violet	
	Sepiapterin		yellow	
	Isosepiapterin		yellow	
	2-AMINO-4 Hydroxypteridine		blue	
newly discovered substances				

B. Analysis of Pteridines Discovered in Wildtype Mutant Drosophila.

Spec. No.	Mutant	eye-color	PTERIDINES IDENTIFIED (check off)							PTERIDINES DISCOVERED BUT NOT IDENTIFIED					
			DROSOPTERIN	BIOPTERIN	XANTHOPTERIN	ISOXANTHOPTERIN	SEPIAPTERIN	ISOSEPIAPTERIN	2-AMINO-4-HYDROXY.						color emit. in U.V. light
															R_f Value

II. QUESTIONS

1. Is a given eye-color determined by the presence of a single pteridine or by a group of pteridines blending together?

2. What particular combination of pteridines determines the eye-color for each mutant?

3. Are pteridines totally absent from white-eyed mutants? Which ones are present, if any?

4. What pteridine seems to be the most common? What mutants, if any, lack it?

5. What pteridine seems to be somewhat rare?

OPTIONAL QUESTIONS:

Consult your instructor about performing experiments on your own in order to find answers to any of these.

1. Would you expect to find a difference in kind and amount of pteridines present in the males and females of a single mutant?

2. Is there a difference in the distribution of pteridines throughout the body of a single mutant? Consider running separate chromatograms for the head, thorax, and abdomen.

3. Can you obtain evidence for the existence of pteridines or other fluorescent substances in plants?

FUNDAMENTAL LIFE PROCESSES

I. Interactions of organisms with their Environment

A. Interactions with the Physical Environment

1. closed versus open sytems

2. the organisms as an open system

3. forms of matter and energy commonly exchanged between organisms and environment

B. Interactions with other Organisms

1. symbiosis

a. mutualism

b. commensalism

2. Neutrality or Toleration

3. Antagonsim

   a. antibiosis

   b. parasitism

   c. predation

   d. competition

C. Behavioral Aspects of Interaction

   1. behavior defined

   2. a model for behavioral interaction with the environment

3. behavioral patterns versus survival or extinction

II. Continuous Maintenance of a State of Internal Order Within the Organism

A. The Concept of Entropy

1. the meaning of entropy

a. entropy defined

b. finding the condition of maximum entropy for a simple system

c. why finding the condition of maximum entropy is extremely difficult for most natural systems

2. general statement regarding the tendencies of a given system with respect to entropy

3. Entropy and Kinetic-Molecular Theory

a. entropy of molecular systems

b. entropy and temperature

1) a model system described:

2) the direction and magnitude of heat transfer within the system

3) the entropy of each component of the system

4) the entropy for the whole system must be positive

5) the heat lost by one component equals the heat gained by the other

6) comparison of E's with H's:

7) since $-E_h$ is smaller in absolute value than $+E_e$; then the quotient applying to the hotter component of the system is larger and positive

8) a definition of temperature:

4. Entropy: the arrow of time

a. how entropy is affected by the passage of time

b. entropy and the irreversibility of time

c. entropy and the universe

B. The Significance of Entropy with Regard to the Organism's Maintenance of Internal Orderliness

1. the second law of thermodynamics

2. the organism and negative entropy

3. the organism as only a part of a whole

4. consequences to man and the biosphere

C. Means By Which Organisms Preserve Their Orderliness in a Changing Environment

1. organisms are not really self-maintaining

2. requirements for maintaining the individual organism

3. requirements for maintaining and perpetuating the species as a whole

III. Survival of the Species Through Perpetuation of Life-Cycles

A. The Nature of Life Cycles

1. life-cycle defined

2. general types of life-cycles

3. longevity of life-cycles

4. natural and artificial intervention in life-cycles

5. the human life-cycle and man

B. Basic Principles Governing Survival of the Species

1. degree of tolerance to situations where essential factors are in low supply or where antagonistic factors are dangerously high.

2. Continued favorable conditions essential to successful completion of the life-cycle

3. specific factors affecting survival

   a. abiotic

   b. biotic

QUESTIONS FOR DISCUSSION:

1. Determine the entropies for all possible conditions that can exist in a box of 6 coins. What is the entropy for the condition of greatest disorder that can occur in this system? Hint: expand the binomial $(H + T)^n$, where n is the number of coins in the box.

   For example: in a system of three coins;

   $$(H + T)^3 = 1 H^3 + 3 H^2T + 3 HT^2 + IT^3$$

   In words, this means that the following conditions are possible when there are only three coins in the box:

mathematical	verbal	diagramatic
$1 H^3$	one way of having all heads	HHH
$3 H^2T$	three ways of having 2 heads and 1 tail	HHT, HTH, THH
$3 HT^2$	three ways of having 1 head and 2 tails	HTT, THT, TTH
IT^3	one way of having all tails	TTT

For such a system, H^2T and HT^2 represent two conditions that can each occur in three different ways. Since these occurrences are more probably than all heads, or all tails, (either of which can occur in only one way: H^3 or T^3), they represent two possible conditions of maximum entropy.

2. In terms of entropy, tell why the probability of finding a box of 16 coins, all with heads up after being shaken for awhile, is a highly unlikely condition.

3. A sperm and an egg unite and a new human being is conceived. It grows, develops, and 9 months later a child is born. How has the entropy of each of the following systems been affected?

   a. the child

   b. the mother

   c. the environment outside the mother's body

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4. It is a common practice of commercially-minded men to purchase marshlands and then proceed to have them obliterated through a process of draining and land-filling. This is all done in the name of "progress" since the ultimate goal, they say, is to "develop" these "useless" areas into sites of value for business, industrial, and recreational facilities.

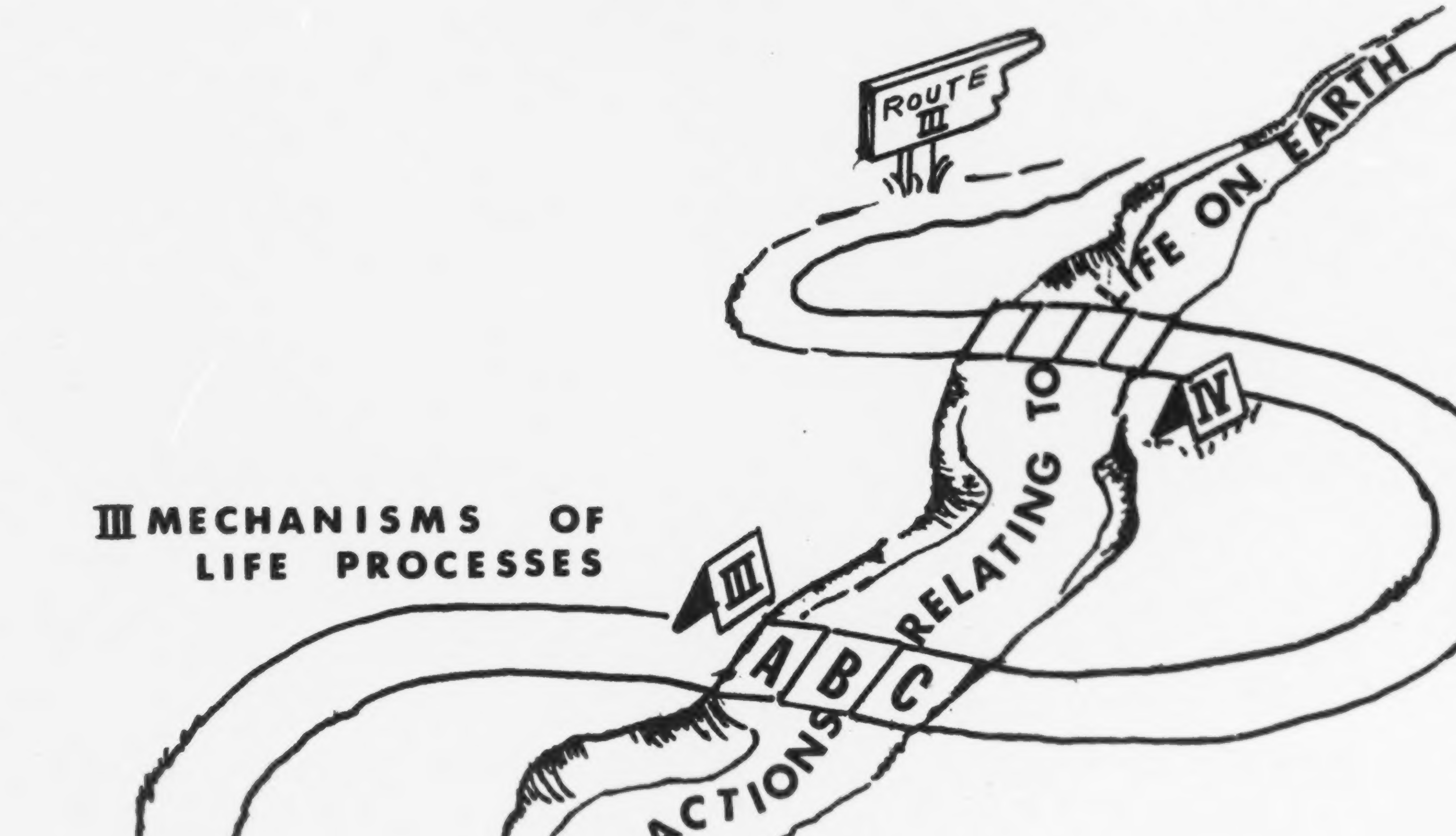
   a. Have you ever visited marshlands and what do you know about them?

   b. What good, if any, are marshlands?

   c. Research and discuss in terms of entropy, the possible consequences of the practice described above to all organisms including man.

   d. Prepare to take issue with the above practice, pro or con, for a classroom debate.

SCIENCE IIA


ROUTE III
LIFE ON EARTH
RELATING TO
IV
III MECHANISMS OF LIFE PROCESSES
III
A B C
INTERACTIONS
II CHARACTERISTICS OF LIVING MATTER
C B A
II
Route II
ENERGY
I
A B
MATTER-
I EXPANSION OF IDEAS ABOUT THE NATURE OF MATTER

- A. Electromagnetic Energy
- B. Energy Intake and Utilization
- C. Transport and Exchange of Matter
- D. Reproduction and Development

Energy Intake and Utilization

ELECTROMAGNETIC ENERGY

Required Reading: Modern Physics - Dull, Metcalf, Williams, pp 303-306 and 357-360

I. Characteristics of Energy - Reviewed

A. Definition

1.

2.

B. Energy Types

C. Energy Transmission

1. The Energy Tree

2. Potential Energy

3. Kinetic Energy

II. The Electromagnetic Theory

A. James Clerk Maxwell (1831-1879)

B. The Electromagnetic Wave

1. Velocity

2. Wavelength

3. Frequency

4. Period

III. Properties of Electromagnetic Waves

A. Reflection

B. Transmission

1. Refraction

2. Interference & Diffraction

C. Absorption

IV. The Electromagnetic Spectrum

A. Divisions

B. Dispersion of White Light

C. Absorption of White Light

ENERGY CAPTURE BY AUTOTROPHS

Photosynthesis

Required Reading:	BSCS Blue Version, pp 181-199 BSCS Green Version, pp 416-422
Recommended Reading:	Isaac Asimov - Biographical Encyclopedia of Science and Technology

I. Historical Development of Ideas About Photosynthesis

A. Aristotle (500 B.C.)

B. Jean Baptista Van Helmont (1620)

C. Joseph Priestley (1772)

D. Jan Ingen Hausz (1779)

E. Jean Senebier (1782)

F. Jan Ingen Hausz (1796)

G. Nicolas de Saussure (1804)

H. J. Robert van Mayer (1845)

I. Contemporary Concepts Concerning Photosynthesis

1. Martin Kamen (1941)

2. Melvin Calvin (1948)

II. An Overall Look at the Photosynthetic Process

A. The Site of Photosynthesis - the Chloroplast

B. Location of the Chloroplast in the Leaf

1. Cross Section of a Typical Leaf

2. Gas Exchange Between the Leaf and the Environment

C. General Equation for the Photosynthetic Reactions

D. The Special Role of Light in Photosynthesis

1. Photoelectrical Changes

2. Photochemical Changes

SPECIALIZATION OF ORGAN STRUCTURE FOR PHOTOSYNTHESIS

INTRODUCTION:

The efficiency with which the raw materials of photosynthesis (carbon dioxide, water, and light) are made available to the photosynthetic cells of plants is no doubt an important factor in the success and continued survival of certain species in nature. Furthermore, the availability of photosynthetic raw materials is to a considerable extent related to plant and organ structure. The concentration of CO_2 in the atmosphere, for example, is very low, being only 0.03%, but the open and porous structure of leaves compensates for this by allowing the entrance and distribution of the gas. Unfortunately this porous structure also promotes water loss from leaves, which can be harmful due to drying out of the protoplasm. As a result the evolution of land plants, in widely different environments, has involved the selection of species with structural features which represent a successful compromise between efficiency for CO_2 absorption and for water retention.

Numerous interesting structural modifications of photosynthetic organs can be observed in the plant kingdom. In this exercise the opportunity is given to observe and study structural adaptations for photosynthesis in three kinds of land plants. These examples also illustrate the trend toward more complicated structure and greater specialization in the higher, more recently evolved groups.

PROCEDURE:

I. Structure of the Photosynthetic Organ in a Liverwort.

a. Observe living thalli (the leaf-like vegetative bodies) of the liverwort *Marchantia*, a primitive plant found in moist habitats, such as river banks and rocky ravines. How is the thallus (leaf) adapted for efficient light absorption?

b. How do the upper and lower surfaces of the thallus differ?

c. Cut off a small section (1 x 1 cm) from one of the thalli and with a dissecting microscope observe the triangular or hexagonal areas on the upper surface. What do you see in the center of each area?

If you cannot interpret the function of the structure, reconsider this point after you have looked at a prepared slide of *Marchantia*. (See Fig. 1)

d. With a sharp razor blade, cut several very thin cross sections of the thallus. Quickly mount these in a drop of water and observe them microscopically. In what portion of the thallus are the chloroplasts most concentrated?

e. Can you think of any advantage in having the primary photosynthetic tissue located in this particular region?

f. Study a prepared slide bearing several cross sections of the thallus. Again compare the location of the photosynthetic and nonphotosynthetic cells. Are the photosynthetic cells in direct contact with the external environment?

Note that there is a series of chambers immediately below the upper epidermis consisting of groups of photosynthetic cells separated by larger, nonphotosynthetic cells. Correlate this with the earlier observation of the triangular or hexagonal areas seen on the upper surface of the thallus.

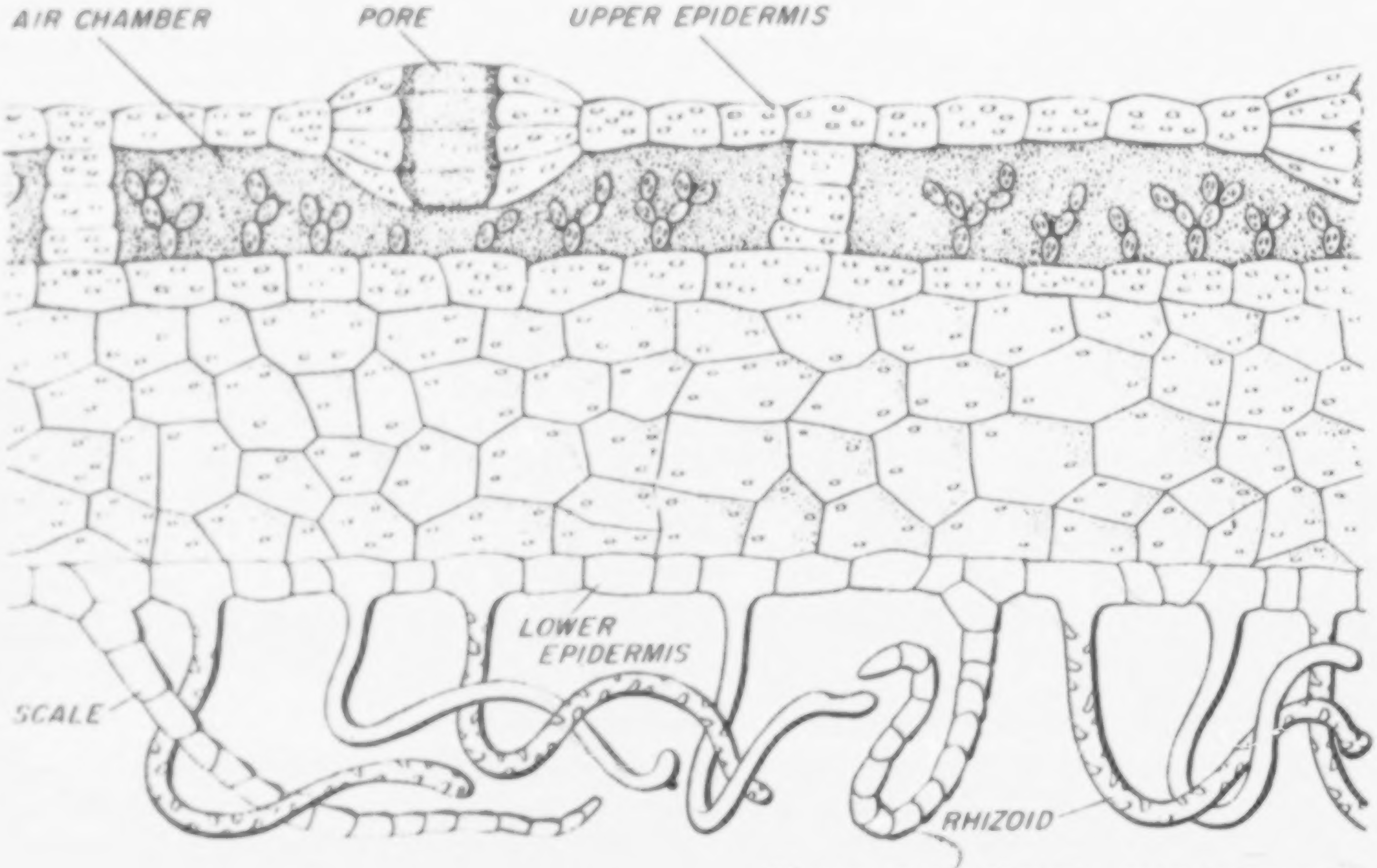


Figure 1 *The Marchantia thallus in cross section.*

g. What is the spatial distribution (arrangement) of the photosynthetic cells with respect to one another?

h. Of what particular advantage might this be for the process of photosynthesis in this organism?

i. What structural feature of each chamber allows relatively free diffusion of gases between the photosynthetic cells and the external atmosphere?

j. Correlate this structure with the appearance of the thallus observed in surface view.

k. Make a sketch of one chamber containing the photosynthetic cells and indicate the pathway of CO_2 and O_2 diffusion.

l. Explain how the food which is formed in photosynthesis may be distributed to the nonphotosynthetic cells of the thallus.

m. Is there any indication that the pores through which gases diffuse may close during periods when photosynthesis ceases?

2. Structure of the Photosynthetic Organ in a Moss.

Examine a slide bearing cross sections of a "leaf" of the moss *Polytrichum*. The leafy structures of this moss actually do not have the internal anatomy characteristic of true leaves, but here they will be called leaves to avoid more cumbersome terminology.

a. Note the platelike outgrowths on one surface of the leaf. Do these cells contain chlorophyll?

b. Is there space between the plates?

c. What is the structure of the terminal (end) cells on the plates?

d. The leaf flattens when moist. Would the photosynthetic cells then have ready access to the atmosphere and to CO_2?

e. The margins of the leaves curl inward during periods of drought. How would this affect water loss from the leaves?

f. How would the inward curling affect the availability of CO_2 to the photosynthetic cells in the plates?

3. Leaf Structure of an Angiosperm Plant. (Plants with Covered Seeds)

A number of major groups in the plant kingdom are omitted when the angiosperms are considered immediately following the mosses. However, many of the structural modifications for photosynthetic efficiency which have evolved in these intermediate groups have been preserved in the angiosperms. For example, a vascular (transportation) system extends into the leaves and provides for rapid movement of water and minerals to the leaves and of the products of photosynthesis away from them. Also, adjacent to the pores (stomata) which permit gaseous diffusion into and out of the leaves are specialized cells (guard cells) which close the pores when plants are in darkness or under moisture stress.

a. Study a prepared slide showing a lilac leaf in cross section. Note that it has an upper and lower epidermis, one or more layers of elongated cells (palisade layer) below the upper epidermis, and a region of loosely packed cells (spongy parenchyma) with large intercellular spaces adjacent to the lower epidermis. In which tissue would you expect the greatest amount of carbohydrate to be synthesized? Give a reason for your answer?

b. What advantage results from the observed location of the primary photosynthetic tissue?

c. Due to the large surface area, extensive evaporation of water from leaves might be expected. Locate the cuticular layer which restricts evaporation from the leaf surface. Look for stomata in the lower and upper epidermis of the lilac leaf. What is their relative distribution between the upper and lower epidermis?

d. What distribution of stomata would you expect to find in leaves which float on the water, such as those of the water lily?

e. Since most of the cells in the leaf are alive, they require a constant supply of water to replace that lost by evaporation. Can you find any evidence of the presence of xylem in the leaf?

f. The living cells of the stem and root require food that has been synthesized in the leaf. Is there any evidence of the presence of phloem tissue in the leaf?

g. Observe mounts of leaves in which all of the tissues have been removed except those having thick walls. Notice that a highly branched network of veins, similar to the circulatory system in higher animals, runs throughout the leaf blade. These veins contain the vascular tissues. Are all the veins of the same size?

h. Carefully peel a small piece of tissue from the lower or upper epidermis of a leaf of one of the plants available in the laboratory. Mount the piece and observe it microscopically. (The epidermis can be separated from the other tissues by tearing the leaf crosswise with a twisting motion. Which epidermis is freed of the other tissues depends on the orientation of the leaf when it is torn.) Make a sketch on your Lab Report Sheet.

i. Locate the stomata and guard cells. Calculate the number of stomata per square centimeter of leaf surface.

j. Repeat the above observations and calculations, using the other epidermis from a leaf of the same plant, and, if time permits, both the upper and lower epidermis from leaves of other species of plants available in the laboratory. Record your results on your Lab Report Sheet.

k. Summarize the structural features observed in the lilac leaf which would seem to contribute to photosynthetic efficiency.

Additional Questions for Discussion

a. What mechanism is responsible for the opening of stomata in light and their closing in darkness?

b. Leaves of some grasses curl under conditions of water deficiency. What structural feature of grass leaves is responsible for the curling?

c. In some angiosperm aquatic plants, part of the plant body is submerged and part is above water. Do the leaves of both parts have stomata and guard cells? Does the vascular system seem to be necessary and to serve a function in aquatic angiosperm plants?

d. In regard to photosynthetic efficiency, compare the general structure of the liverwort thallus, the moss leaf, and the angiosperm leaf. In what ways are they similar? Dissimilar?

LAB REPORT SHEET

Name ______________________

Science IIA Hour ____

Date ______________________

TITLE: ______________________

GENERAL PURPOSE:

SPECIAL INVESTIGATIONS:

1. Structure of the Photosynthetic Organ in a Liverwort.

a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h.

i.

j.

k.

l.

m.

2. Structure of the Photosynthetic Organ in a Moss.

a.

b.

c.

d.

e.

f.

3. Leaf Structure of an Angiosperm Plant.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j. *Distribution of Stomata in Angiosperm Leaves*

PLANT*	NUMBER OF STOMATA (PER SQ CM)	
	Upper Epidermis	*Lower Epidermis*

k.

Additional Questions:

a.

b.

c.

d.

PHOTOSYNTHESIS - A UNIQUE BIOCHEMICAL PROCESS

I. Some Molecules Involved in the Process of Photosynthesis

   A. Chlorophylls - for energy capture

   B. Glucose - for energy storage

   C. Enzymes - regulate all reactions

   D. ATP - the molecule for high-powered energy storage

II. The Reactions Involved in the Process of Photosynthesis

   A. The Light Reaction

      1. Reactants and Products

      2. Site

      3. Mechanism of Operation

      4. Flow diagram of Reaction

B. The Dark Reaction

1. Relation to the Light Reaction

2. Reactants and Products

3. Site

4. Mechanism of Operation

5. Flow diagram of Reaction

III. The Relationship of Photosynthesis to Other Life Processes -

A. Respiration - Photosynthesis Produces O_2 as a By-Product

B. Food Chains - Photosynthesis Produces $C_6H_{12}O_6$, the Biochemical Source of all Foods

Laboratory Exercise

PHOTOSYNTHESIS - Some Laboratory Exercises

1. Leaves Make Starch - But Not Always.

MATERIALS:

Each group of students will require the following materials:

- 4 screwtop preserving jars with gaskets
- 4 small vials or 50 ml beakers
- plant leaves - plain + variegated
  (geranium (or coleus) plants should be darkened for two days preceding the experiment)
- 5% sodium bicarbonate solution (baking soda)
- 10% sodium hydroxide solution (caustic soda)
- Iodine solution (Lugol's)
- 95% alcohol

PROCEDURE:

In general, place petioles (stems) of healthy leaves in vials of water. Place the vials in the preserving jars so that the leaf blades are not shaded. Pour reagent in the bottom of the preserving jars without touching the leaves. Close jar tightly.

Specifically arrange the four jars as follows:

#1 - Leaf should be green; reagent should be 5% sodium bicarbonate (supplies C
strong natural light should be provided.

#2 - Leaf should be green; reagent should be 5% sodium bicarbonate; jar should
be placed in a dark cupboard.

#3 - Leaf should be green; reagent should be 10% sodium hydroxide (removes CO_2
light should be required.

#4 - Leaf should be variegated; reagent should be 5% sodium bicarbonate;
light should be required.

All the illuminated jars to stand in bright natural light supplemented by a 100 wa
bulb at two feet overnight. 24 to 48 hours later remove leaves from containers and place them separately in a boiling water bath. (NOTE- BE SURE TO RETAIN THE LEAF'S "IDENTITY" AS BEING FROM #1, 2, 3, 4 JAR!) for 3-4 minutes. Next remove the chlorophyll from the leaves by placing the leaves in a beaker of alcohol whic
has been placed in a hot water bath. (CAUTION! DO NOT LET THE ALCOHOL COME NEAR THE BUNSEN BURNER.)

Test each of the four leaves for the presence of starch. Record your observation
on the following lab report sheet.

Laboratory Exercise

2. The Pigments of the Chloroplast

MATERIALS:

2 screw-top preserving jars
2 test tubes with stoppers or small bottle
glass capillary tubes (these can be made from 3 mm O.D. tubing)
Carbon tetrachloride
95% alcohol
Anhydrous sodium sulfate
Filter paper (Whatman #1)
green leaves - using a variegated leaf you may cut off the white parts and run the white parts as a control.

PROCEDURE:

Crumble the green tissue, place in test tube, barely cover with alcohol and leave overnight in a dark place. Pour off the clear green solution and save - this contains the pigments. Add a bit of anhydrous sodium sulfate and close tightly. Cut squares of filter paper which will fit easily into the preserving jar when rolled into a cylinder. Draw a pencil line one inch from the bottom of the sheet before use.

Using the glass capillary tube make a narrow line of chlorophyll extract along the pencil line. Repeat 8-10 times until mark is deep green. THE SHEET MUST BE DRY BETWEEN APPLICATIONS! When the sheet has thoroughly dried and all the applications have been made, roll the sheet into a cylinder with extract-line near the bottom. Secure the cylinder with staples or a paper clip. Stand the cylinder in the preserve jar having added enough carbon tetrachloride to cover the bottom of the jar, but not to reach the pencil line.

Remove and dry the cylinder before the liquid ($C\ Cl_4$) reaches the top of the paper (10-15 min.) Examine the paper immediately since colors fade in the light. The pigments should appear as colored bands in the following sequence from top to bottom:

carotene (orange-yellow at the solvent front)
xanthophylls (one or more yellow bands)
chlorophyll a (blue green)
chlorophyll b (yellow green)

Complete the following lab report sheet.

Laboratory Exercise

3. Carbon Dioxide and Photosynthesis

MATERIALS:

4 preserving jars with lids and gaskets
glass beads
2 balloons
2 dropping pipettes
2 test tubes
2% slaked lime or 2% barium hydroxide, filtered
tire pump
2 small bottles
germinating seeds
green leaves

PROCEDURE:

Fill one balloon by mouth, the other with the tire pump. Clamp each balloon shut and attach to a dropping pipette. Allow each balloon to discharge slowly through 2% slaked lime in a test-tube. Note your observations on the lab report sheet.

Prepare the four preserving jars as follows:

#1 - Add 25 c.c. of moist germinating seeds. Close jar and place in the light.

#2 - Add 25 c.c. glass beads, close jar and place with jar #1.

#3 - Place the petiole (leaf "stem") of green leaf in small bottle and place this in the preserving jar. Close and place in continuous light with #1 and 2.

#4 - Repeat #3 but place in a dark place.

After 24 hours pour 5 ml. of 2% slaked lime into each jar, opening the lid gently and for as brief a time as possible. Swirl the jars gently, then tip to observe the precipitate in the added reagent. Record observations on lab report sheet which follows.

LAB REPORT SHEET

Name ____________

PHOTOSYNTHESIS -
Leaves Make Starch, But Not Always

Science IIA Hour ____

Date ____________

PURPOSE: ____________

OBSERVATIONS:

Leaf #1 ____________

Leaf #2 ____________

Leaf #3 ____________

Leaf #4 ____________

CONCLUSIONS:

Leaf #1 ____________

Leaf #2 ____________

Leaf #3 ____________

Leaf #4 ____________

QUESTIONS:

1. Why was starch tested for here to indicate that photosynthesis had occurred, instead of glucose?

___

___

___

2. How do you explain the effect of NaOH on photosynthesis?

___

___

___

3. How do you account for the presence or absence of starch in leaf #4? ___

___

___

___

4. This experiment demonstrates the necessity of several factors for photosynthesis to occur. Name these.

___

___

___

LAB REPORT SHEET

Name ______________________________

PHOTOSYNTHESIS
The Pigments of the Chloroplast

Science IIA Hour ____

Date ______________________________

PURPOSE: ______________________________

OBSERVATIONS: ______________________________

CONCLUSIONS: ______________________________

QUESTIONS:

1. How many bands of pigment were you able to locate? ______________________________

2. Can you hypothesize as to the reason the pigments separated out from each other? ______________________________

3. Which of the 4 pigments is most active in photosynthesis? ______________________________

4. What wavelengths of light do each of the pigments absorb?

LAB REPORT SHEET

PHOTOSYNTHESIS
Carbon Dioxide and Photosynthesis

Name ______

Science IIA Hour ____

Date ______

PURPOSE: ______

OBSERVATIONS: ______

CONCLUSIONS: ______

QUESTIONS:

1. Why was breath and air tested with the balloon? ______

2. Explain the action of the germinating seeds. ______

3. CO_2 gas is involved in which phase of the photosynthetic process - the light or the dark reaction?____

4. Define the role CO_2 plays in photosynthesis.____

ENERGY CAPTURE BY HETEROTROPHS

Recommended Reading:	BSCS Yellow Version, Ch. 3, pp 52-63
Recommended Film:	"Catching A Meal"

I. The difference between autotrophs and heterotrophs

II. Both autotrophs and heterotrophs require energy.
(See following reading - "Energy: A Requirement For Life".)

III. Heterotrophs obtain food in various ways -

A. Symbionts

1. Parasitism

2. Mutualism

3. Commensalism

B. Saprophytes

C. Bulk Feeders

IV. Structural Adaptations for Food Capture

Related Reading

ENERGY CAPTURE BY HETEROTROPHS

Energy: A Requirement For Life

Animals which move and maintain a high body temperature obviously require a source of energy for these functions. In less obvious ways, all living things use energy to maintain the chemical reactions and complex organization which distinguishes living things.

Although the need for energy and the ability to use it are features basic to all life forms, this does not mean that every organism obtains this energy by the same means. The competition for an energy source in the biological world is intense, and evolution has provided various mechanisms in organisms for obtaining energy.

It is well known that the sun's light is the primary energy resource for all organisms, including man. However, light energy cannot be used directly to power cell functions. Light must first be converted into chemical energy in the form of sugar. This is accomplished in photosynthesis. A few bacteria obtain energy for the formation of food through the oxidation of elements like sulfur and iron, or compounds like hydrogen sulfide or methane. These are chemosynthetic plants. The photosynthetic and chemosynthetic organisms together are known as autotrophs - self sufficient organisms capable of producing food by utilizing the energy from sunlight or from simple chemical substances in their environment.

Heterotrophic organisms cannot manufacture their own food, but are dependent on autotrophs for the carbon compounds that serve as a source of energy. When two organisms occur in close physical association, they are said to exist in a symbiotic relationship. Saprophites are those heterotrophs which obtain food from dead material in their environment. The many bacteria and fungi which bring about the decay of animal and vegetable remains belong in this group. Other heterotrophs obtain part or all of their food directly from the living tissues of other plants or animals with which they are closely associated: these are parasites.

It should be made clear that not all organisms fall into one of the categories above. Depending on conditions, some organisms may be either parasitic or saprophytic. For example, some bacteria which may be parasitic in animals may be grown in the lab on a nonliving medium. It is often difficult to determine the degree to which an association of organisms is beneficial or harmful to the organisms involved.

Laboratory Exercise

ADAPTATIONS FOR FOOD CAPTURE

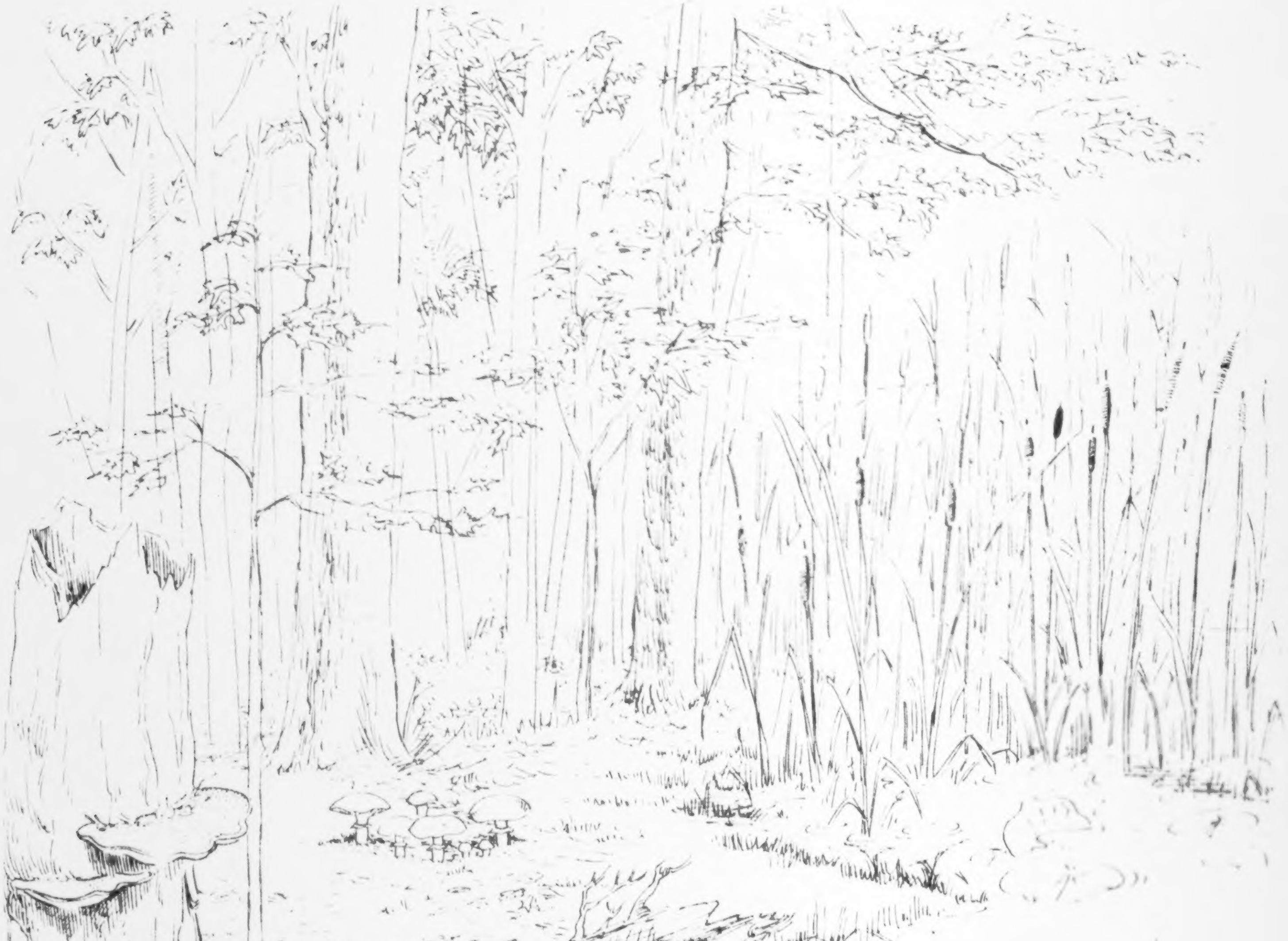
MATERIALS:

You will have a wide variety of plant and animal specimens made available to you in preserved and slide form. The plant material will include mushrooms, purple bacteria, green algae, nitrogen fixing bacteria in clover root nodules, lichens, Spanish moss, wheat rust, pitcher plants, fungi, tomato plants. The animal specimen will of course all be quite small but will contain invertebrates (no backbone) and representatives from all the major vertebrate groups - fish, amphibians, reptiles, birds, mammals.

With regard to the plant specimens, in most cases the color of the plant can guide you in determining whether the plant is an autotroph or a heterotroph. If you are undecided about some of the plants, study their association with their environment in the picture which follows.

In determining what type of feeders the animal specimens are, study their oral areas most carefully for any structural formations which may provide clues. Classify all plant + animal specimens as one of the following:

1) Photosynthetic Autotroph
2) Chemosynthetic Autotroph
3) Parasitic Heterotroph
4) Saprophytic Heterotroph
5) Bulk Feeding Heterotroph



A few examples of the various ways in which plants obtain energy for life processes and of different types of associations among plants.

LAB REPORT SHEET

Name ______________

Science IIA Hour ___

Date ______________

ADAPTATIONS FOR FOOD CAPTURE

PURPOSE: ______________

OBSERVATIONS:

Classification of Organisms by Energy Source

Organism(s)	Classification Based on Energy Source	Reason for Your Classification

CONCLUSION: Make one general conclusion which can be drawn from this lab.

____

QUESTIONS:

1. What is meant by a food chain in a natural community? Discuss the energy relationship involved.________________________________

2. Some biologists believe that chemosynthetic organisms were among the first inhabitants of the earth. If this is true why aren't there more of them today? Why are there more photosynthetic than chemosynthetic organisms?

The material on page 209-210 may be found

TITLE Patterns and Processes

AUTHOR Biological Sciences Curriculum Study

PUBLISHER Holt, Rinehart & Winston

PAGE NO. S-25 S-26

MECHANISM OF ENERGY CAPTURE

Energy Flow and Nature's Metabolism

Required Reading: Ecology, Odum, E. "Energy Flow and Nature's Metabolism." Chapter 3.

Cell Structure and Function, Loewy and Siekevitz, "Life and the Second Law of Thermodynamics", Chapter 2.

I. Basic Principles Governing the Flow of Matter and Energy in Ecosystems

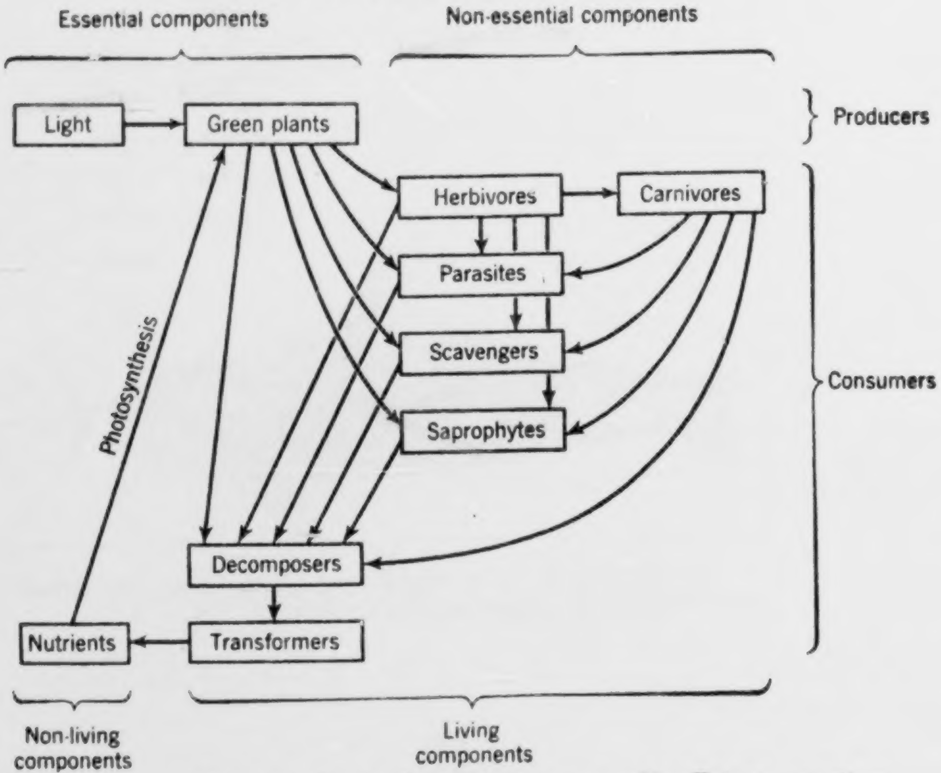
   A. Structural Organization of Ecosystems and Pathways for Energy Intake, Utilization and Loss

      1. the concept of food chains

      2. the concept of trophic level

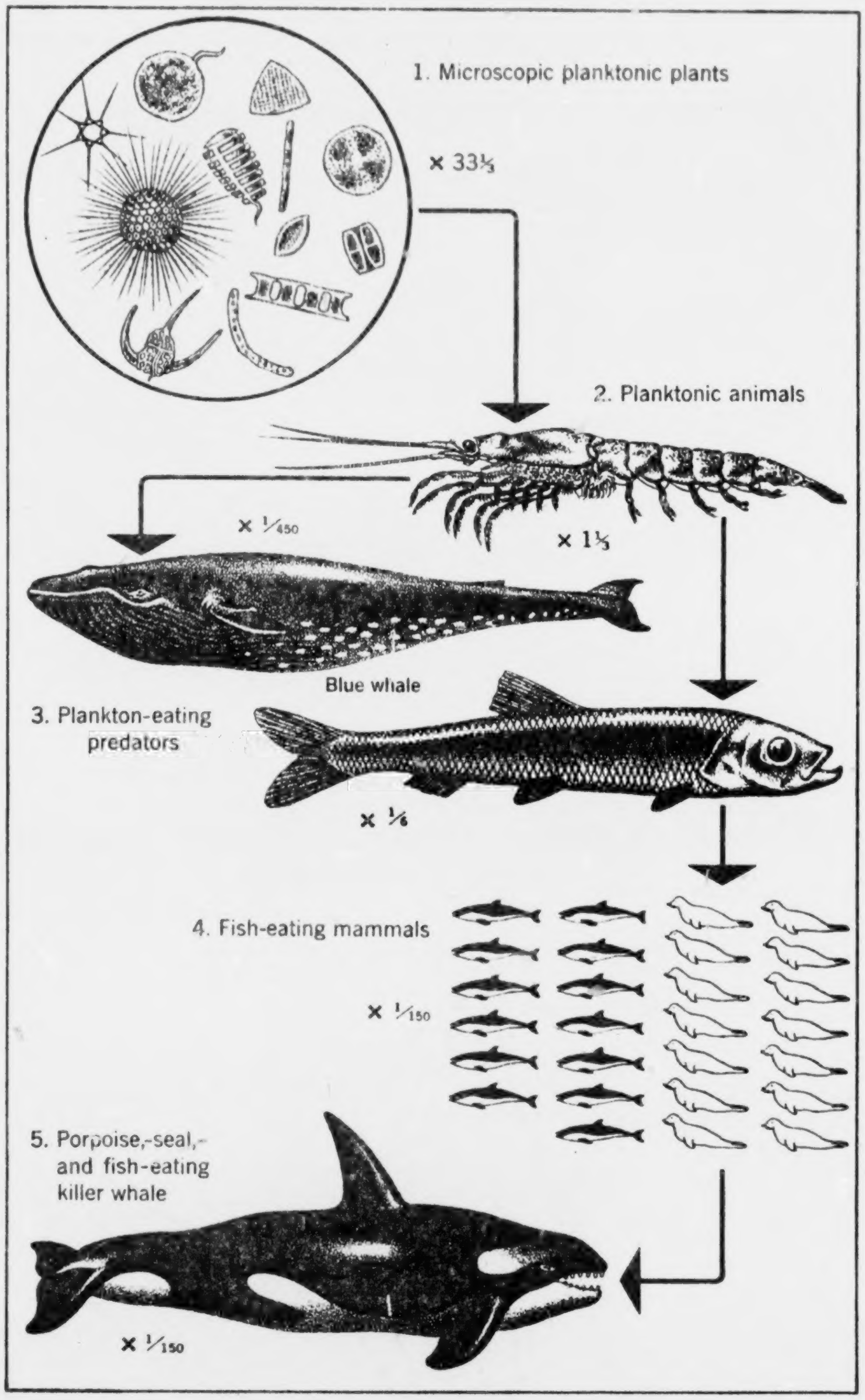
      3. the concept of food pyramid

GENERAL CASE SHOWING INTERRELATIONSHIPS OF BIOTIC AND ABIOTIC COMPONENTS


Essential components
Non-essential components
Light
Green plants
Producers
Herbivores
Carnivores
Parasites
Scavengers
Saprophytes
Consumers
Photosynthesis
Decomposers
Nutrients
Transformers
Non-living components
Living components

Principal steps and components in a self-sufficient ecosystem.

A SPECIFIC CASE: ABIOTIC COMPONENTS NOT SHOWN


1. Microscopic planktonic plants
× 33⅓
2. Planktonic animals
× 1/450
× 1⅓
Blue whale
3. Plankton-eating predators
× ⅙
4. Fish-eating mammals
× 1/150
5. Porpoise, seal, and fish-eating killer whale
× 1/150

Two food chains of different lengths. One killer whale's stomach contained thirteen porpoises and fourteen seals.

B. Functional Organization of Matter-Energy Flow in Ecosystems

1. Energy-dependent factors affecting the density of a given species and the rate at which it lives within a given ecosystem

    a.

    b.

2. General characteristics of the Flow of Matter and Energy in Ecosystems

    a. energy

        1)

        2)

        3)

    b. matter

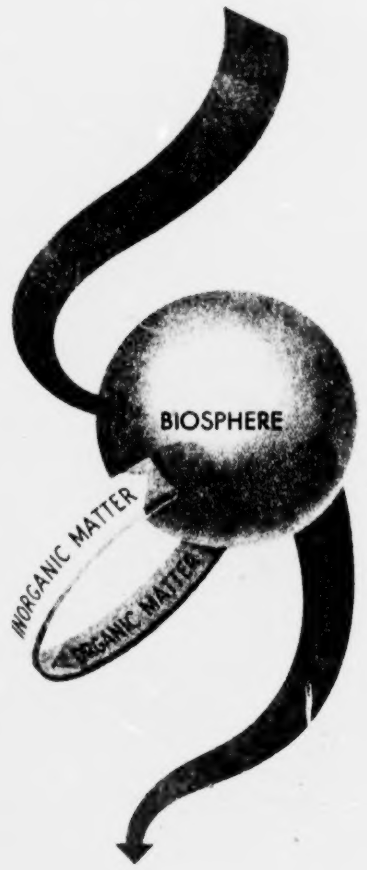
        1)

        2)

THE ECOSYSTEM AS A UNIT OF FUNCTION:

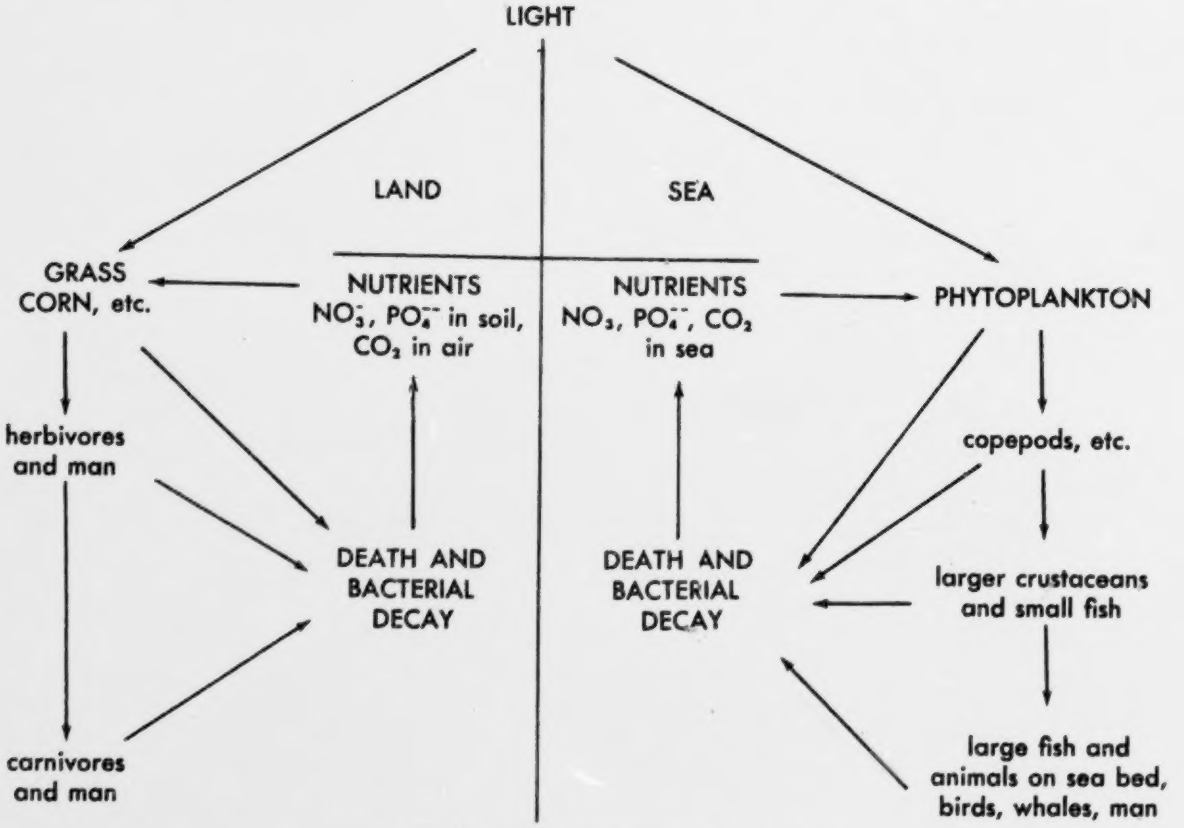
A. INTERRELATIONSHIPS BETWEEN ENERGY FLOW AND BIOGEOCHEMICAL CYCLES OCCURRING WITHIN ECOSYSTEMS

1. General Case:


BIOSPHERE
INORGANIC MATTER
ORGANIC MATTER

How does the flow of energy through the biosphere differ from the flow of matter?

2. Specific Case:


LIGHT
LAND
SEA
GRASS CORN, etc.
NUTRIENTS NO_3^-, PO_4^{--} in soil, CO_2 in air
NUTRIENTS NO_3, PO_4^{--}, CO_2 in sea
PHYTOPLANKTON
herbivores and man
copepods, etc.
DEATH AND BACTERIAL DECAY
DEATH AND BACTERIAL DECAY
larger crustaceans and small fish
carnivores and man
large fish and animals on sea bed, birds, whales, man

The organic cycle on land and in the sea.

II. The One-Way Flow of Energy in Ecosystems as the Result of the Operations of the Laws of Thermodynamics

A. Life and the Laws of Thermodynamics

1. the first law

2. the second law

3. the third law

B. The Possibility of a "fourth law".

1. a unique property of living matter with regard to energy capture and utilization

2. the significance of the trend toward increasing complexity as life-forms evolve

3. significance with regard to the rate at which free energy becomes degraded.

III. Constructing Food Pyramids

A. Methods of Determining the Number of Units of one Trophic Level that is required to support a unit of the next trophic level in a food-chain

1. choice of units and merits of each

   a. count

   b. volume

   c. weight

   d. fuel value

2. the destiny of energy as it flows through a food-chain

   a. distribution along energy pathways

   b. significance of the 2nd law of thermodynamics

   c. assimilation and maintenance

3. The concept of ecological efficiency

    a. ecological efficiency defined

    b. problems of collecting the data required to calculate ecological efficiency

    c. limitations that diminishing ecological efficiency imposes upon the length of food chains

ECOLOGICAL EFFICIENCIES OF TROPHIC LEVELS WITHIN AN ECOSYSTEM:

Ecological efficiency for hypothetical food chain $x \rightarrow y \rightarrow z$ in terms of:

$$\frac{\text{calories of } y \text{ consumed by } z \text{ per unit time}}{\text{calories of } x \text{ consumed by } y \text{ per unit time}} \times 100 = \%$$

where x, y, and z are successive trophic levels in the food chain.

1. General case:

The material on this page may be found

TITLE **Patterns and Processes**

AUTHOR **Biological Sciences Curriculum Study**

PUBLISHER **Holt, Rinehart, Winston**

PAGE NO. **56**

B. General Characteristics of an Energy-Flow Diagram or model for an Idealized Ecosystem

1. applicability in principle to all ecosystems

2. depicts general characteristics of food chains and food pyramids

3. shows qualitatively the energy intake, utilization, losses and ecological efficiency at each trophic level

4. accounts quantitatively for the energy intake, utilization, losses and ecological efficiency at each trophic level.

    a. input

    b. utilization (net gains)

    c. losses

    d. output

The material masked out on this page may be found:

Title Ecology

Author Eugene Odum

Publisher Holt, Rinehart and Winston, N.Y. 1963

Page Number p. 38

QUESTIONS FOR DISCUSSION:

1. How would you propose to measure the ecological efficiency of Daphia as a predator of the alga, Chlamydomonas?

2. Determine the ecological efficiencies of each of the following trophic levels.

Plants		Herbivores		Carnivores		Secondary Carnivores	
20810	8833	3368	1478	383	67	21	6
Entering	Stored	E	S	E	S	E	S

Calculations:

Do your findings support or refute the food pyramid hypothesis?

3. Estimate the reduction in efficiency for a supercarnivore of the 3rd order. Can you think of any such cases in nature?

4. Basically why are food chains usually limited to four stages?

5. How would a food chain be shortened by an animal that is not restricted in its diet? Why would this be difficult if not impossible for most animals? Give examples as to how man has shortened or is shortening the food chain he depends on.

PERIODIC CHART

SHELLS

s

d

TRANSITION

LIGHT METALS

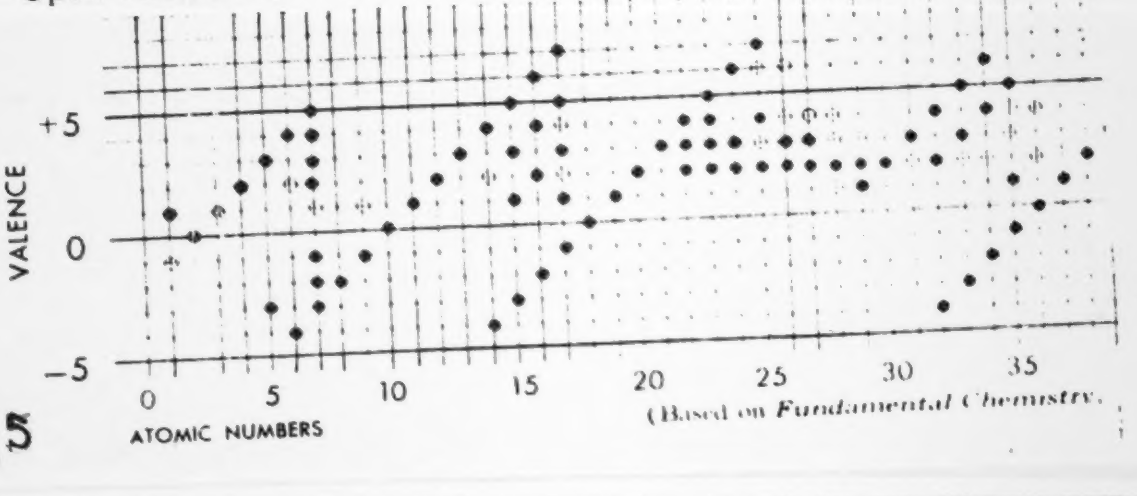
PRINCIPAL QUANTUM No. *n*	X-RAY NOTATION	I A	II A	III B	IV B	V B	VI B	VII B
1	K	1 1 H 1.00797						
2	L	2 1 3 Li 6.939	2 2 4 Be 9.0122					
3	M	2 8 1 11 Na 22.9898	2 8 2 12 Mg 24.312					
4	N	2 8 8 1 19 K 39.102	2 8 8 2 20 Ca 40.08	2 8 9 2 21 Sc 44.956	2 8 10 2 22 Ti 47.90	2 8 11 2 23 V 50.942	2 8 13 1 24 Cr 51.996	2 8 13 2 25 Mn 54.9380
5	O	2 8 18 8 1 37 Rb 85.47	2 8 18 8 2 38 Sr 87.62	2 8 18 9 2 39 Y 88.905	2 8 18 10 2 40 Zr 91.22	2 8 18 12 1 41 Nb 92.906	2 8 18 13 1 42 Mo 95.94	2 8 18 13 2 43 Tc (99)
6	P	2 8 18 18 8 1 55 Cs 132.905	2 8 18 18 8 2 56 Ba 137.34	57-71 See Lanthanide Series	2 8 18 32 10 2 72 Hf 178.49	2 8 18 32 11 2 73 Ta 180.948	2 8 18 32 12 2 74 W 183.85	2 8 18 32 13 2 75 Re 186.2
7	Q	2 8 18 32 18 8 1 87 Fr (223)	2 8 18 32 18 8 2 88 Ra 226	89-100 See Actinide Series				

6 P	LANTHANIDE SERIES (Rare Earth Elements)
7 Q	ACTINIDE SERIES

NOTE: A value given in parentheses denotes the mass number of the isotope of the longest known half-life, or of the best known one.

*The brackets are meant to indicate only the general order of subshell filling. The filling of subshells is not completely regular, as is emphasized by the use of red ink to denote shells which have electron populations different from the preceding element. In the case of He, subshell population is not by itself indicative of chemical behavior, and that element is therefore included in the inert gas group, even though helium possesses no p-electrons.

Open circles represent valence states of minor importance, or those



(Based on *Fundamental Chemistry*,

OF THE ELEMENTS

REVISED, 1964

p

HEAVY METALS

NON METALS

INERT GASES

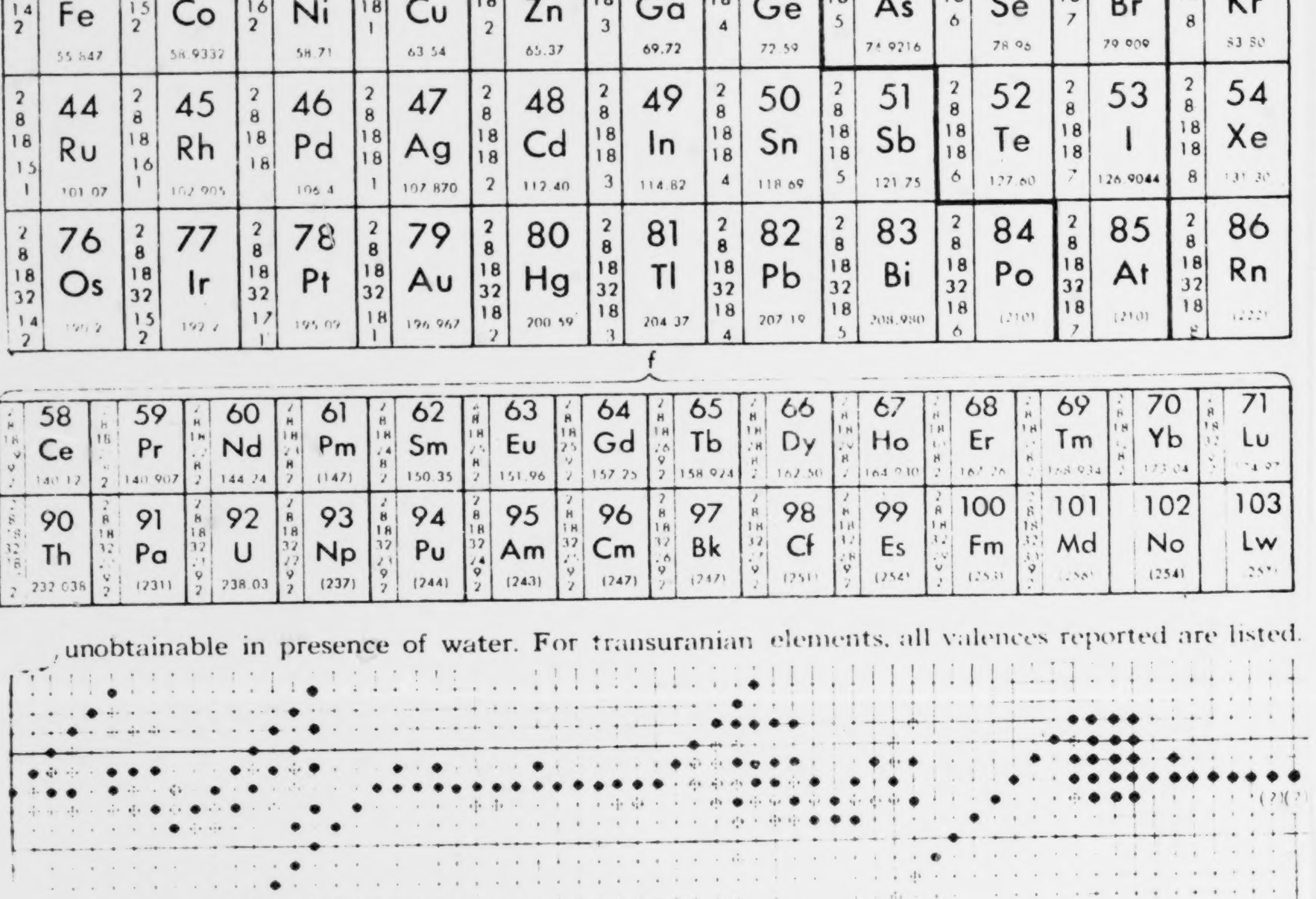
VIII	VIII	VIII	I B	II B	III A	IV A	V A	VI A	VII A	INERT GASES
										2 He 4.0026 2
					5 B 10.811 2 3	6 C 12.01115 2 4	7 N 14.0067 2 5	8 O 15.9994 2 6	9 F 18.9984 2 7	10 Ne 20.183 2 8
					13 Al 26.9815 2 8 3	14 Si 28.086 2 8 4	15 P 30.9738 2 8 5	16 S 32.064 2 8 6	17 Cl 35.453 2 8 7	18 Ar 39.948 2 8 8
26 Fe 55.847 2 8 14 2	27 Co 58.9332 2 8 15 2	28 Ni 58.71 2 8 16 2	29 Cu 63.54 2 8 18 1	30 Zn 65.37 2 8 18 2	31 Ga 69.72 2 8 18 3	32 Ge 72.59 2 8 18 4	33 As 74.9216 2 8 18 5	34 Se 78.96 2 8 18 6	35 Br 79.909 2 8 18 7	36 Kr 83.80 2 8 18 8
44 Ru 101.07 2 8 18 15 1	45 Rh 102.905 2 8 18 16 1	46 Pd 106.4 2 8 18 18	47 Ag 107.870 2 8 18 18 1	48 Cd 112.40 2 8 18 18 2	49 In 114.82 2 8 18 18 3	50 Sn 118.69 2 8 18 18 4	51 Sb 121.75 2 8 18 18 5	52 Te 127.60 2 8 18 18 6	53 I 126.9044 2 8 18 18 7	54 Xe 131.30 2 8 18 18 8
76 Os 190.2 2 8 18 32 14 2	77 Ir 192.2 2 8 18 32 15 2	78 Pt 195.09 2 8 18 32 17 1	79 Au 196.967 2 8 18 32 18 1	80 Hg 200.59 2 8 18 32 18 2	81 Tl 204.37 2 8 18 32 18 3	82 Pb 207.19 2 8 18 32 18 4	83 Bi 208.980 2 8 18 32 18 5	84 Po (210) 2 8 18 32 18 6	85 At (210) 2 8 18 32 18 7	86 Rn (222) 2 8 18 32 18 8

d

f

d	f													
57 La 138.91 2 8 18 18 9 2	58 Ce 140.12 2 8 18 19 9 2	59 Pr 140.907 2 8 18 [illegible] 2	60 Nd 144.24 2 8 18 22 8 2	61 Pm (147) 2 8 18 23 8 2	62 Sm 150.35 2 8 18 24 8 2	63 Eu 151.96 2 8 18 25 8 2	64 Gd 157.25 2 8 18 25 9 2	65 Tb 158.924 2 8 18 26 9 2	66 Dy 162.50 2 8 18 28 8 2	67 Ho 164.930 2 8 18 29 8 2	68 Er 167.26 2 8 18 30 8 2	69 Tm 168.934 2 8 18 31 8 2	70 Yb 173.04 2 8 18 32 8 2	71 Lu 174.97 2 8 18 32 9 2
89 Ac (227) 2 8 18 32 18 9 2	90 Th 232.038 2 8 18 32 18 [illegible] 2	91 Pa (231) 2 8 18 32 20 9 2	92 U 238.03 2 8 18 32 21 9 2	93 Np (237) 2 8 18 32 22 9 2	94 Pu (244) 2 8 18 32 23 9 2	95 Am (243) 2 8 18 32 24 9 2	96 Cm (247) 2 8 18 32 25 9 2	97 Bk (247) 2 8 18 32 26 9 2	98 Cf (251) 2 8 18 32 27 9 2	99 Es (254) 2 8 18 32 28 9 2	100 Fm (253) 2 8 18 32 29 9 2	101 Md (256) 2 8 18 32 30 9 2	102 No (254)	103 Lw (257)

unobtainable in presence of water. For transuranian elements, all valences reported are listed.



2nd Edition, by H. G. Deming, Published by John Wiley & Sons, Inc.)

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Carl H. Pfeiffer
Wisconsin State Department of Education

SE

ED0 53982

SCIENCE

MATTER
ENERGY
TIME

MATTER-ENERGY INTERACTIONS RELATING TO LIFE ON EARTH

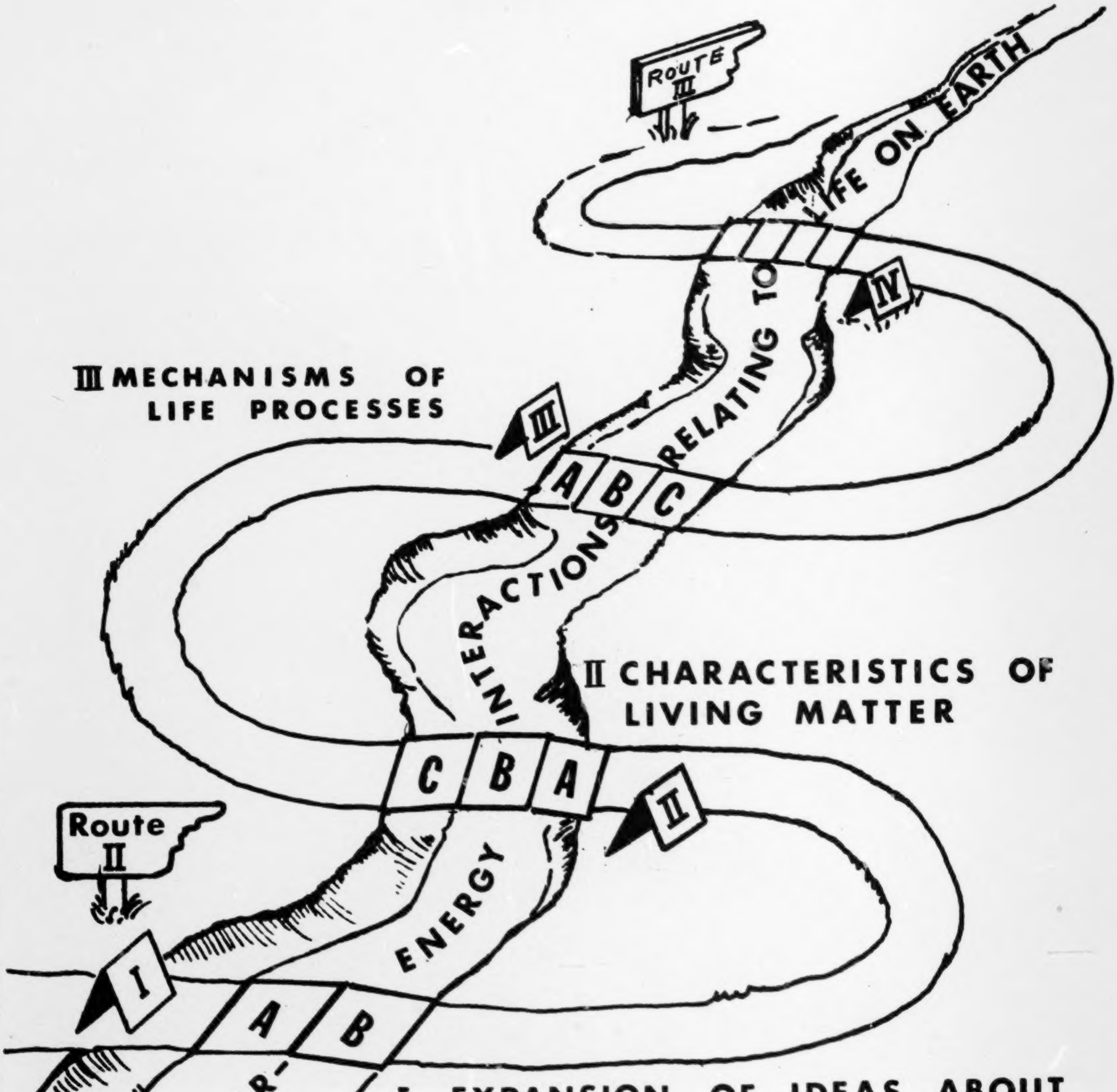
CHANGE

[illegible]
[illegible]
[illegible]

SE 012 309
Part 2

217

SCIENCE IIA


ROUTE III
LIFE ON EARTH
RELATING TO
IV
III MECHANISMS OF LIFE PROCESSES
III
A
B
C
INTERACTIONS
II CHARACTERISTICS OF LIVING MATTER
C
B
A
II
Route II
ENERGY
I
A
B
MATTER-
I EXPANSION OF IDEAS ABOUT THE NATURE OF MATTER

A. Electromagnetic Energy

B. Energy Intake and Utilization

C. Transport and Exchange of Matter

D. Reproduction and Development

DIGESTION

The Function of Digestion

Required Reading: BSCS Green; Ch. 14, pp 452-459

BSCS Blue; Ch. 6, pp 111-115

BSCS Yellow; Ch. 6, pp 104-108

Recommended Reading: BSCS Yellow, Ch. 20,

Cell Physiology & Biochemistry, Wm. D. McElroy, Editor

I. Alimentation

A. as food capture intake

B. as food breakdown

II. Digestion is Food Breakdown

A. Mechanical Digestion

B. Chemical Digestion

1. Intracellular Digestion

2. Extracellular Digestion

III. Digestion In Man

A. Mouth

1. teeth

2. tongue

3. salivary glands

B. Esophagus

C. Stomach

1. gastric glands

2. chief cells

D. Small Intestine

1. pancreas

2. liver

3. intestinal glands

4. end products of digestion

5. absorption in the small intestine

IV. The Role of Enzymes in Digestion

A. Definition of an Enzyme

B. Characteristics of an Enzyme

1. Specificity

2. Sensitivity to pH and temperature

C. The Modus Operandi of an Enzyme

V. Reference Table of Digestive Enzymes

SECRETION	ENZYME	FOOD ACTED UPON	PRODUCT
saliva	amylase	starch	maltose
gastric juice	pepsin	protein	polypeptides
pancreatic juice	amylases	starches	maltose
	lipase	fats	glycerol and fatty acids
	trypsin	protein	polypeptides
	peptidases	polypeptides	amino acids
intestinal juice	sucrase	sucrose	simple sugars
	maltase	maltose	simple sugars
	lactase	lactose	simple sugars
	lipase	fats	glycerol and fatty acids
	peptidases	polypeptides	amino acids

DIGESTION

Gastric Digestion

(Source - American Biology Teacher, March 1962)

PURPOSE:

What is the effect of pH upon the digestion of protein by pepsin? In this exercise, the protein consists of egg white coagulated in capillary tubes. These capillary tubes are placed in each of four test tubes, as indicated:

MATERIALS:

At the front desk:

1. fingerbowl containing raw egg white.
2. capillary tubing - 6 pieces, each about 8" long. The usual 6 mm laboratory tubing may be substituted for capillary tubing.
3. Erlenmeyer flask or pot, 8" deep, tripod, Bunsen burner.
4. triangular files or ampule knives - 4.

For each group:

1. test tube rack, or glass tumbler for holding test tubes.
2. 4 test tubes
3. glass graduate - 10 ml
4. labels
5. bottles, each containing:

HCl	0.08%
pepsin	2.0%
$NaHCO_3$	0.8%
water	

Part 1: Preparation of Solutions

One member of each group labels the four test tubes by recording the *class, group, and tube number*, e.g., Bio 106, 3, IV.

A different student in each of the groups prepares each of the four solutions. Wash the graduate each time it is used.

	Solution	Preparation	
I	Acid (0.4% HCl)	HCl (0.8%) Water	5ml
II	Pepsin (1.0%)	Pepsin (2.0%) Water	5ml
III	Pepsin (1.0%) HCl (0.4%)	Pepsin (2.0%) HCl (0.8%)	5ml 5ml
IV	Pepsin (1.0%) $NaHCO_3$ (0.4%)	Pepsin (2.0%) $NaHCO_3$ (0.8%)	5ml 5ml

Part II: Preparation of Egg-White Tubes

The protein used is coagulated egg white prepared from a fresh egg. One member of each group goes to the front demonstration table and draws egg-white into a piece of glass tubing about 8" long. The albumin is then coagulated by placing the tubes into water at 85°C for 5 minutes. The tubes are then cut into sections about 1" long. One section is placed into each of the four test tubes which have meanwhile been prepared by other students in the group.

Part III: Incubation

Place all test tubes into a glass tumbler which will fit into our incubator. Incubate for 24 hours at 37°C, or three days at room temperature.

Part IV: Observations

Your tubes will be observed by your class on the following day. Use a millimeter ruler to make any measurements which are significant to you. Make drawings.

LAB REPORT SHEET
GASTRIC DIGESTION

Name ______________________

Science IIA Hour ___

Date ______________________

PURPOSE: ______________________

PROCEDURE: Indicate the main steps of the procedure but refer to the direction sheets for details such as how the solutions were prepared.

____

OBSERVATIONS: Include a drawing. ______________________

QUESTIONS:

1. What is a protein? ______________________

2. What is an enzyme?

3. How do chemists use "pH" to indicate whether a solution is acid or alkaline?

4. What is the effect of pH upon gastric protease?

5. How does the stomach's acidity affect the action of ptyalin?

6. To prepare an "artificial gastric juice" what substances would you use?

7. Ask your instructor about the Ninhydrin test. What are proteins changed to during digestion? How could you verify this?

8. Criticize this experiment from the viewpoint of controls.

DIGESTION

Basic Chemical Change of Digestion

Required Reading: BSCS Yellow Version, Ch. 5, pp 93-98

I. A Review of the Structure of the Basic Food Groups

A. Proteins

B. Fats

C. Carbohydrates

II. The Site of Digestion of These Food Molecules

A. Proteins

B. Fats

C. Carbohydrates

III. The Actual Process of Enzymatic Breakdown - Hydrolysis

A. Hydrolysis is the Breakdown Reaction for All Organic Molecules

1. Proteins

2. Fats

3. Carbohydrates

B. Hydrolysis reactions can be run with different enzymes

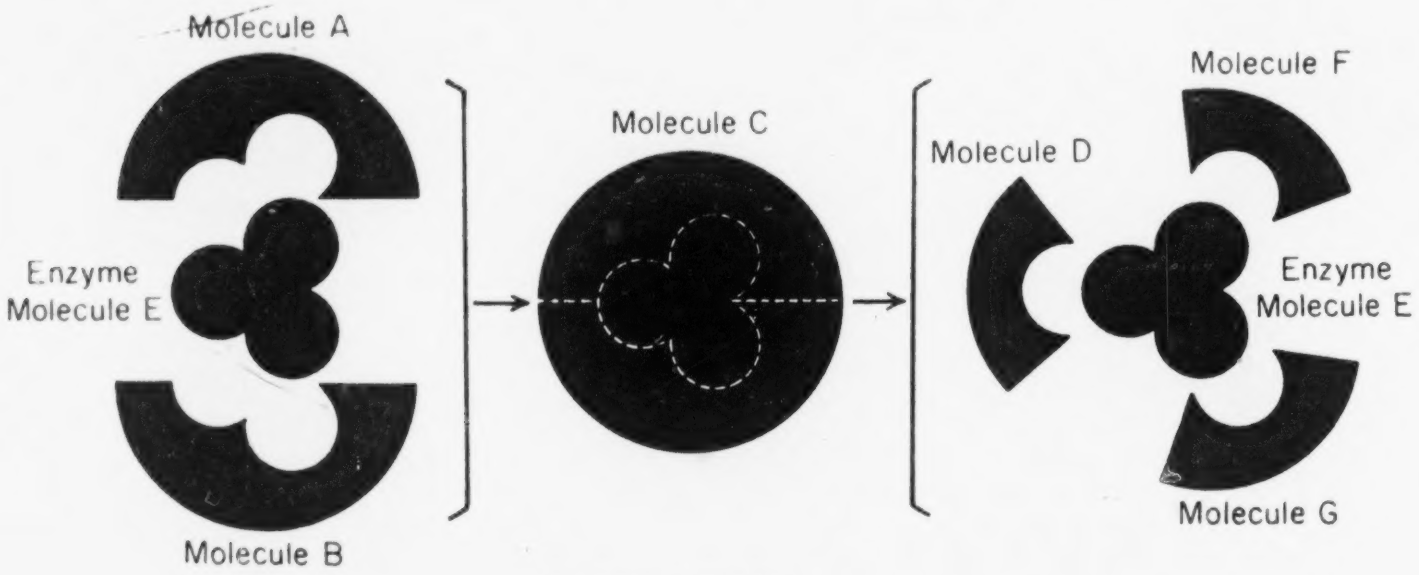
C. The different hydrolytic enzymes require different environments

A Reading

DIGESTION

The Role of Enzymes in Digestion

Some of the most important substances in the cell from the standpoint of cellular activities (metabolism) are enzymes. Enzymes are commonly associated with the digestive system. It is true that specific digestive enzymes exist, but these act outside the cell and represent only a tiny fraction of the total number of kinds of enzymes produced within living cells. Enzymes are proteins and are responsible for the numerous chemical reactions which take place in a living cell. In a very simplified version, the activity of an enzyme may be diagramed as below:



ENZYME ACTION

Enzymes aid and speed up chemical reactions, but are recovered intact following a reaction. Thus, an infinitesimal number of molecules of a given enzyme can be responsible for many reactions. Some chemical reactions in the cell result in the synthesis of substances necessary for the life of the cell. Other chemical reactions result in the hydrolysis, or breakdown, of complex substances to simple ones, e.g., starch to sugar. Additional reactions may result in further breakdown and thus make energy available for the life of the cell.

Laboratory Exercise

THE ENVIRONMENT OF AN ENZYME

INTRODUCTION:

Enzymes not only regulate chemical reactions inside an organism, but also retain their activity when removed from the organism and used in the laboratory. In either situation, however, their activity is subject to environmental conditions such as temperature and pH. The concentration of an enzyme also has some effect on its action.

You will investigate the effect of varying environmental conditions upon the action of the enzyme diastase in starch digestion.

MATERIALS:

Part A:
- Beaker, 400 ml
- Ice
- Bunsen burner
- 0.3 percent diastase solution - enzyme
- 0.2 percent starch solution - subtrate
- 2 test tubes
- Graduated pipette
- Thermometer
- Porcelain spot plate
- Lugol's iodine solution
- Waterproof ink marker

Part B:
- Buffer solutions of known pH
- 2 test tubes
- 0.3 percent diastase solution
- 0.2 percent starch solution
- Graduated pipette
- Porcelain spot plate
- Lugol's iodine solution

Part C:
- Successive dilutions of 0.3 percent diastase solution (0.03, 0.003, etc)
- 0.2 percent starch solution
- Beaker, 50 ml
- Graduated pipette
- Porcelain spot plate
- Lugol's iodine solution

PROCEDURE:

Part A. Temperature and Enzyme Activity

This inquiry can be more detailed within a brief time if you and your classmates work in groups. Each group will be assigned specific temperature conditions with which to work. Typical temperatures for this study can be 10°, 20°, 30°, 40°, 50°, and 60°C. Prepare a 200 ml water bath at the assigned temperature, using a 400 ml beaker and either ice or heating to bring the water to the proper temperature. At intervals, heat again, or add ice as necessary to maintain the temperature.

Put about 5 ml of freshly prepared 0.3 percent diastase solution in a test tube. Place the test tube in the water bath and wait approximately 5 minutes until the diastase solution is at the temperature of the water bath. At the same time take a 25 ml sample of 0.2 percent starch solution, put it in a second test tube and place this with the first in the water bath, having marked each so that they will not be mixed.

While these two tubes are being brought to the water bath temperature, design a control for this inquiry.

When the enzyme and the starch solution are both at the assigned temperature, pour 4 ml of the enzyme solution into the starch solution and return the tube with the rest of the enzyme solution to the water bath. Note the time at which you added the diastase to the starch. Remove a sample of the mixture with the medicine dropper (pipette) every 30 to 60 seconds - the exact interval to be determined by you - and place a drop of the mixture in the depression on a porcelain spot plate. Immediately place a drop of iodine on the sample and record the color. Rinse the plate and repeat this procedure until no starch is detected. Record the time at which this end point was reached.

With this data you can calculate the rate of the reaction. For example, 4 ml of 0.3 percent enzyme solution and 25 ml of 0.2 percent starch solution give you this ratio:

	4 (0.3)	to 25 (0.2)
or	1.2	to 5.0
or	1	to 4, roughly

You have approximately 1 ml of enzyme per 4 ml of starch. If the starch solution is digested in 2.5 minutes, this would be at a rate of 4 ml for each 1 ml of enzyme in 2.5 minutes, or 1.6 ml a minute per 1 ml of enzyme. If the starch solution is digested in 5 minutes the rate is 0 8 ml a minute per 1 ml of enzyme.

Using this procedure, determine the rate of reaction per 1 ml of enzyme at your assigned temperature and place this information on the board.

When all the class data are on the board, prepare a data table and construct a rate graph using the assigned temperatures and the class data. In making a graph put the independent variable (temperature) on the horizontal axis and the dependent variable (reaction rate) on the vertical axis of the graph. Rate will be in terms of ml of starch digested per minute for each 1 ml of enzyme.

Look at the data you have assembled. Answer all questions on lab sheet which follows.

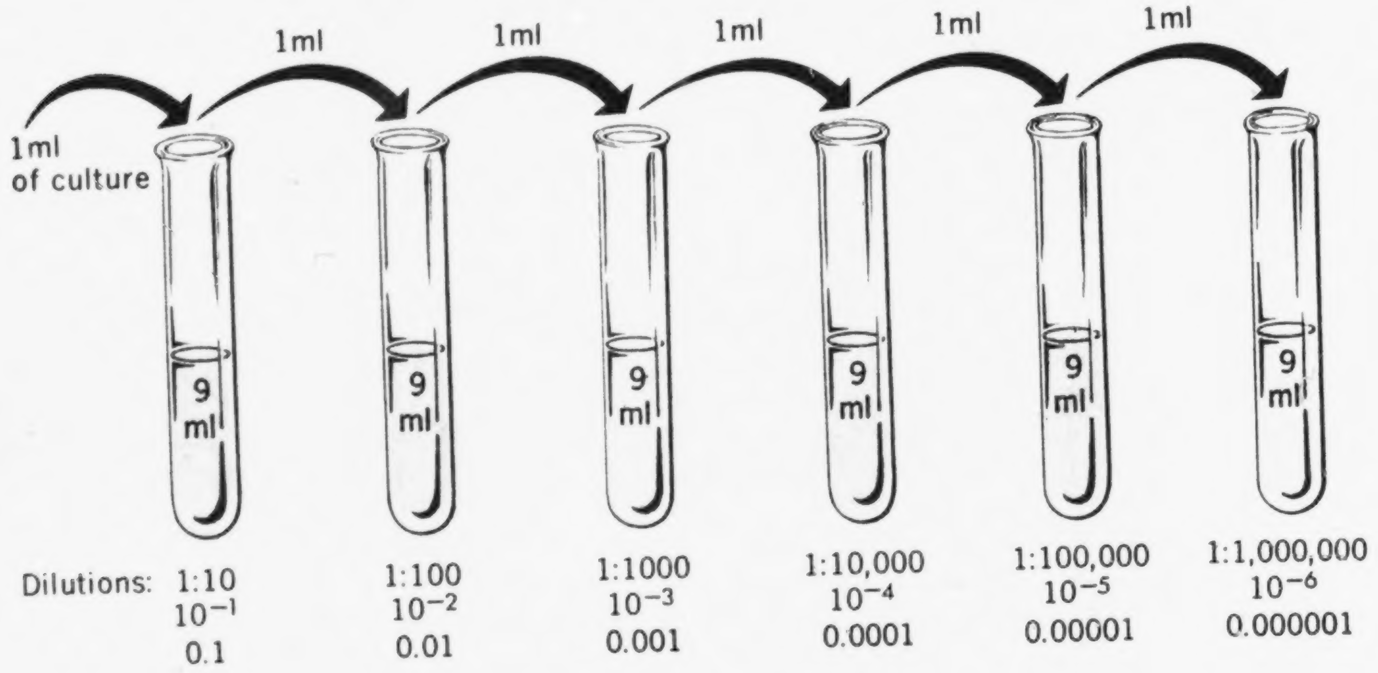
Part B. pH and Enzyme Activities

Selected buffer solutions of a given pH (hydrogen ion concentration) are available. Mix 10 ml of the buffer solution assigned to your group with 10 ml of the 0.2 percent starch solution in a test tube. Add 2 ml (40 drops) of fresh 0.3 percent diastase solution. Every 30 to 60 seconds remove one drop of the mixture and test it for starch as in Part A. Repeat until starch is no longer present. Record the time at which the end point of the reaction is reached, and record your data both in your notebook and on the board.

When all the class data are on the board, calculate the rate of reaction as you did in Part A. (The starch solution is now 0.1 percent instead of 0.2 percent - why?) Construct a rate graph with the hydrogen ion concentration as the independent variable and the reaction rate of starch digested per minute as the dependent variable.

Part C. Concentration and Enzyme Activity

Some of the original diastase solution has been diluted by units of 10, in much the same manner as illustrated in the figure shown below. Select the enzyme dilution assigned to your team and set up your controls.


1ml
1ml
1ml
1ml
1ml
1ml
of culture
9 ml
9 ml
9 ml
9 ml
9 ml
9 ml
Dilutions: 1:10 10^{-1} 0.1
1:100 10^{-2} 0.01
1:1000 10^{-3} 0.001
1:10,000 10^{-4} 0.0001
1:100,000 10^{-5} 0.00001
1:1,000,000 10^{-6} 0.000001

Enzyme dilution method

The diastase and starch solutions should be at room temperature. Mix 20 ml of starch solution and 4 ml of the diluted enzyme solution in a 50 ml beaker. Each 30 to 60 seconds remove 1 drop of the reaction mixture and test it for starch as you have done previously.

Record the time it takes to reach the end point, and calculate the rate of reaction for your assigned dilution. Place your data on the board and, when all the class data are available, prepare both a data table and a rate graph. Use the diastase solution as the independent variable and the reaction rate in ml per minute as the dependent variable.

So far you have worked with only 3 possible environmental variations and their effects on enzyme activity. What other environmental conditions may influence enzyme activity? Can these be tested in the manner used to test pH, temperature, and enzyme concentration? If so, design an experiment, with controls, to test the effects of another environmental variable in this fashion. If not, what other kind of an experimental design can you suggest to test one of these environmental variables?

LAB REPORT SHEET

Name ______________________________

Science IIA Hour _____

Date ______________________________

THE ENVIRONMENT OF AN ENZYME

PURPOSE: ______________________________

PROCEDURE: ______________________________

OBSERVATIONS: ______________________________

QUESTIONS: Part A. Temperature and Enzyme Activity

1. At what temperature does the reaction proceed most rapidly? _______________ Account for the shape of the curve on the graph. _______________

2. How do the controls you designed indicate whether only the diastase was responsible for the disappearance of the starch? _______________

3. How can you verify whether high or low temperatures destroy the enzyme? _______________

Part B. pH and Enzyme Activities

4. At what hydrogen ion concentration does the reaction go most rapidly? _______________

5. How could you verify that the enzyme and not the change in hydrogen ion concentration was responsible for the disappearance of the starch?__________

6. What does the shape of the curve of the graph tell you about the relationship of hydrogen ion concentration to diastase activity?__________

Part C. Concentration and Enzyme Activity

7. From this data, how does dilution of the enzyme solution affect the ability of diastase to digest starch?__________

8. What is the significance of the shape of the curve you have plotted for dilution and its effect on enzyme activity?__________

9. How can you be certain that the curve you have plotted represents only the effects of the dilution of the enzyme on its activity?__________

Laboratory Experiment

THE DEGRADING OF STARCH

INTRODUCTION:

The usual references list the formula for starch as $(C_6H_{10}O_5)_x$ where x has a value of around 15,000. The vast size of this molecule is discernable on a macro level by the observation that starch solutions are pretty "sticky" and made of a mass of tangled molecules. This jumbled mass can be reduced to smaller less interwoven molecules by the breakdown of starch into the monosaccharide glucose, or disaccharides.

DIRECTIONS:

Part I. Draw a piece of 5-mm glass tubing into a capillary tube whose outside diameter is about 1 cm. The tube should be able to hold about 3 ml.

Prepare a 1% solution of starch for the class as follows: Suspend 1 gram of cornstarch in 10 ml water; slowly add this while stirring to 100 ml of boiling water. Let cool to room temperature.

Fill the capillary tube with the starch solution and record the time required for the tube to empty. Collect the contents in a beaker as they leave the tube. Test the contents with both Benedict's and Lugol's Solutions.

Part II. Add 3 ml saliva to 10 ml of the 1% starch solution and place the mixture in a test tube in a water bath at 40°C for 10 minutes.

At the end of 10 minutes immediately fill the capillary tube with the second solution and again record the time it takes the tube to empty.

Collect the liquid and test with Benedict's and Lugol's Solutions.

QUESTIONS: (Answer questions on your Lab Report Sheet)

1. Why would a decrease in viscosity be expected upon addition of saliva?
2. What is the reason for specifying the temperature of the water bath?
3. Would a longer incubation period in the water bath have a proportional effect on the change in viscosity?
4. Explain the results obtained with the Benedict's and Lugol's Reagents.

COMPLETE YOUR LAB REPORT ON LAB REPORT SHEETS WHICH WILL BE HANDED OUT TO YOU.

ENERGY RELEASING PROCESSES

Mechanisms of Electron Transfer

Oxidation - Reduction in Inorganic Systems

Required Reading: Modern Chemistry, Chapter 22, pp 377-395

Recommended Reading: Chemistry - Silver Burdett, Chapter 18, pp 356-371
Chemistry - An Experimental Science, Chapter 12, pp 199-222

INTRODUCTION:

In most chemical reactions the electron configuration of the atoms involved is changed. One type of reaction in which this occurs is the combining of oxygen with other elements producing an oxide of that element. We have learned that, historically, this type of reaction was called Oxidation. Other reactions involving changes in the electron arrangement of atoms have also been considered; formation and decomposition reactions, exchange reactions, and the dissociation and ionization of chemical compounds. In some chemical reactions the changes in electron configuration are a result of sharing, in other cases electrons are actually exchanged, that is, in the course of the reaction certain atoms give up electrons and become positive ions while others gain electrons and become negative ions.

In this part of our study we will be directing our attention to the type of chemical reaction which results in the transfer of electrons. Reactions of this type are called "Oxidation-Reduction", or "Redox" reactions. We shall seek to discover certain general principles which characterize this type of reaction in inorganic systems and then relate this mechanism of chemical change to our investigation of chemical changes associated with the energy capture and releasing process in living things.

Laboratory Investigation

THE MECHANISM OF ELECTRON TRANSFER IN REPLACEMENT REACTIONS

INTRODUCTION:

Most chemical reactions involve the translocation of electrons which make up the outer orbits of the atoms which interact. In the process the chemical stability of the substance is changed, it may be either increased or decreased but it is natural for chemical reactions to proceed in such a direction as to increase chemical stability.

We have found that in some types of interactions chemical change is the result of electrons being shared. The compounds which are formed in this way are called covalent compounds. Diatomic gas molecules are formed by this process; as are most compounds composed of weak metals and nonmetals.

Electrovalent compounds are formed when the electrons from the outer orbit of one atom are transferred to the outer orbit of another atom. In this investigation we are going to consider these types of reactions.

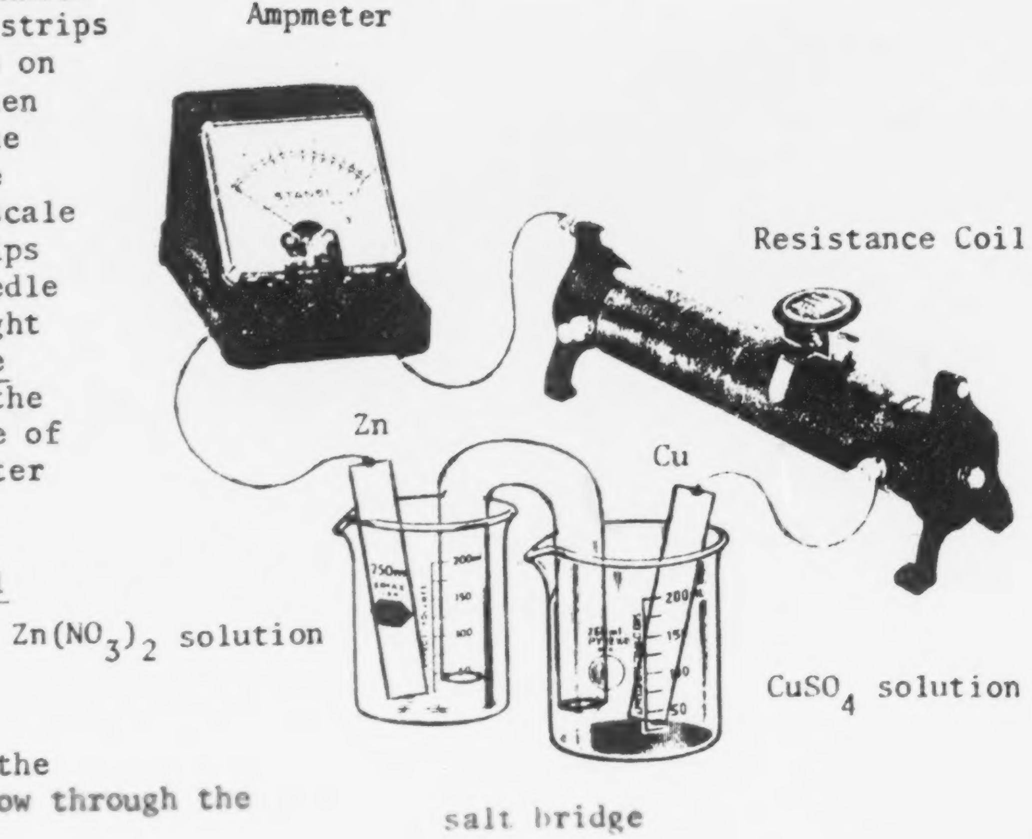
PROCEDURE:

Add 200 ml of a 0.1M $CuSO_4$ solution to one beaker and 200 ml of a 0.1M $Zn(NO_3)_2$ to a second beaker. Place a strip of zinc metal in the beaker of $Zn(NO_3)_2$ and a strip of copper metal in the solution of $CuSO_4$. Each beaker now contains neutral metal atoms in physical contact with a solution containing ions of the same metal. Since the two solutions are contained in separate beakers there is no opportunity for an exchange of ions or electrons between the two metals. The purpose of this investigation is to determine if there would be a transfer of electrons between these two metals if a pathway were provided and also, if electrons were transferred, to determine which metal was losing and which was gaining electrons. Finally we would like to know something about the relative rate at which electrons were being lost and gained. In order to carry out this type of investigation it will be necessary to retain each metal in its separate container so that the reaction there can be analyzed. However, it will be necessary to provide a pathway for the movement of electrons through the solution in one beaker into the solution in the other beaker. This can be done by filling a "U" tube with a salt solution and using it to "bridge" across the two beakers. This connection is called a "salt bridge".

In order to determine the direction in which electrons move one could provide an external electrical pathway between the two metals with an ampmeter in between. In order to protect the ampmeter from an excessive flow of electrons which could damage the meter movement it is necessary to place a resistance coil in series with the instrument.

The diagram on the following page shows how this completed chemical-electrical system would look.

The direction of the electron flow can be established by connecting the wires from the metal strips in such a way that the needle on the meter swings clockwise when the circuit is closed. If the needle moves counterclockwise against the zero end of the scale the wires from the metal strips must be reversed. If the needle swings all the way to the right and goes "off scale" increase the amount of resistance in the circuit to slow down the rate of electron flow through the meter movement.



Electrons in an external electrical circuit always flow from negative to positive. Since the negative and positive posts of the ampmeter are identified the direction of the electron flow through the system can be established.

Assume that the copper strip in this system was losing electrons and that they were being transferred to the zinc. If this were the case, copper atoms would have to lose electrons thus forming copper ions. The electrons would travel along the wires of the external circuit toward the zinc and the copper ions would go into the solution. As a result the copper strip would become lighter. The flow of electrons to the zinc would result in an accumulation of electrons on the surface of the metal. Zinc ions in contact with the zinc would pick up these electrons and form neutral atoms of zinc which would be attracted to the surface of the zinc strip. Thus the zinc strip would become heavier as the copper became lighter.

The relative rate of electron loss and gain during the reaction can be determined by measuring the loss and gain in the relative weights of the metal strips. This weight loss or gain could then be described in terms of the number of moles of each metal involved in the reaction.

$$\# \text{ moles} = \frac{\text{grams}}{\text{mol wt}}$$

DATA SHEET

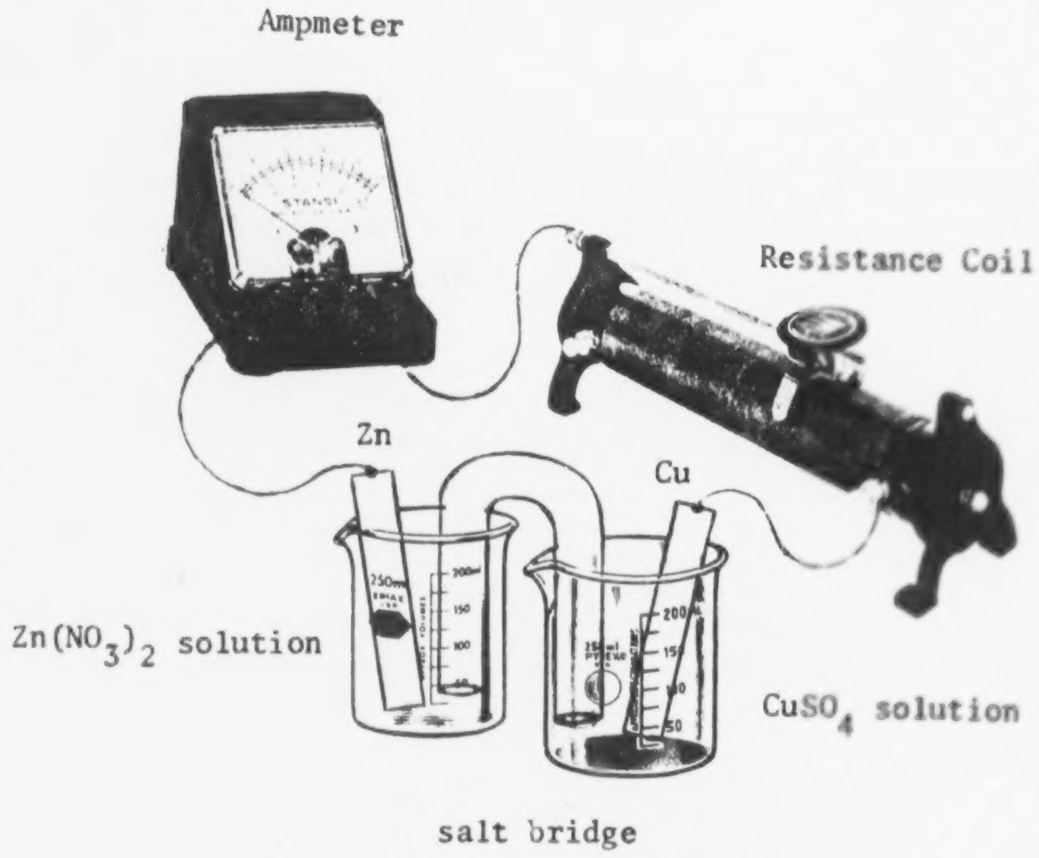
	zinc (g)	copper (g)
original wt of strip		
final wt of strip		

orig amp reading ________

final amp reading ________

INTERPRETATION OF RESULTS:

1. Direction of Electron Flow
(Use arrows to indicate the direction of the electron flow in the system)


Ampmeter
Resistance Coil
Zn
Cu
$Zn(NO_3)_2$ solution
$CuSO_4$ solution
salt bridge

2. Moles of metal involved in the reaction

# moles lost by __________ = ____________

# moles gained by __________ = ____________

QUESTIONS:

1. How many grams of $CuSO_4$ would be required to prepare 200 ml of a 0.1M solution of $CuSO_4$?

2. Describe the change in the concentration of ions in the beaker containing the zinc strip during the course of the reaction.

3. On the basis of the ampere readings at the start and end of the experiment what conclusion can be drawn with reference to the rate of the reaction during the interval of the experiment?

4. Write an equation to represent the reaction in:

   a) the beaker containing the zinc

   b) the beaker containing the copper

ENERGY RELEASING PROCESSES, Cont.

The Nature of Oxidation

I. The Oxidation Process

A. Neutrality of the atom

B. Definition of Oxidation

1. initial concept

2. electron transfer

C. Oxidation and Chemical change

II. Reduction

A. Definition

B. Relationship of reduction to oxidation

III. Oxidizing and reducing agents

IV. Structure of Molecules and Radicals

A. Oxidation Number (review)

1. in molecules

2. in radicals

B. Structural Patterns

1. in molecules

2. in radicals

Exercise

Name ____________________

Science IIA Hour ___

Date ____________________

The Nature of Oxidation

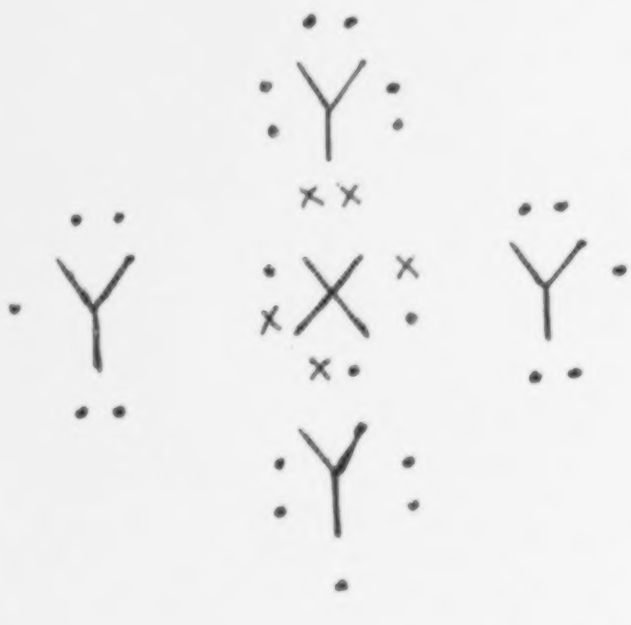
Calculate the oxidation numbers of the indicated element in the following compounds or radicals:

1. Br in K BrO_3 __________
2. N in N_2O_3 __________
3. C in CO_3^{-2} __________
4. Cl in ClO_3^{-1} __________
5. P in $Fe_3(DO_4)_2$ __________
6. N in NO_4^{-1} __________
7. Cr in Na_2CrO_4 __________
8. I in IO_2^{-1} __________

Draw the electron dot representation of the following:

1. carbon dioxide
2. sulfur trioxide
3. the sulfite radical
4. the nitrite radical

Element X combines with Element Y to form a radical whose electron dot representation is given below:



1. What is the oxidation number of Element X? __________
2. What is the valence of the radical XY_4?

For each of the following reactions write the half reactions for oxidation and reduction and name the oxidizing and reducing agents:

1. $Zn + S \longrightarrow ZnS$

2. $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

3. $WO_3 + 3H_2 \longrightarrow W + 3H_2O$

4. $Na_2SO_4 + 4C \longrightarrow Na_2S + 4CO$

5. $H_2SO_4 + 8HI \longrightarrow H_2S + 4I_2 + 4H_2O$

ENERGY RELEASING PROCESSES, Cont.

Oxidation - Reduction Reactions

I. Replacement reactions

A. Activity series of the metals

B. Metal replacing hydrogen in an acid

1. generalization

2. equations

C. Metal replacing hydrogen in water

1. generalization

2. equations

D. Metal replacing a metal in a compound

1. generalization

2. equations

II. Significance of the Activity Series in Oxidation-Reduction reactions

III. Other Oxidation-Reduction reactions

Exercise

Name ______________________

Science IIA Hour ____

Date ______________________

Oxidation - Reduction Reactions

For each of the following reactions write the half-reaction for oxidation, the half-reaction for reduction, the net ionic reaction and the balanced molecular equation:

1. nickel reacting with hydrochloric acid

2. the action of potassium on water

3. the action of chromium and sulfuric acid

4. zinc reacting with silver nitrate

5. aluminum reacting with lead acetate

6. the action of copper with sulfuric acid

Complete the following equations. Determine the net potential of such a cell and decide whether a reaction can occur:

1. $Cu + Ag^{+} \longrightarrow$

2. $Hg + H^{+} \longrightarrow$

3. $Sn + Fe^{+2} \longrightarrow$

For each of the following write the half-reactions, determine the net reaction and predict whether the reaction can occur:

1. $Mg + Sn^{+2} \longrightarrow$

2. $Mn + Cs^{+1} \longrightarrow$

3. $Zn + Fe^{+2} \longrightarrow$

4. $Fe + Fe^{+3} \longrightarrow$

ENERGY RELEASING PROCESSES

Oxidation-Reduction in Organic Systems

Required Reading:	BSCS Yellow Version, Ch. 5, pp 99-102
Recommended Reading:	Unresting Cells, R. W. Gerard, Chapter 5
Recommended Film Strip:	"Biochemistry of Enzyme Action"

I. Oxidation-reduction Involves Energy Change

II. Some Examples of Oxidation-Reduction in Living Systems

A. A wide variety of examples of oxidation-reduction reactions in living things

B. Oxidation-reduction reactions specifically for Energy

1. Photosynthesis
the equation:

CO_2 is reduced:

H_2O is oxidized:

$C_6H_{12}O_6$ a much higher energy level than HC

the role of enzymes:

2. Respiration
   the equation:

O_2 is reduced:

$C_6H_{12}O_6$ is oxidized:

CO_2 - return to a lower energy level:

the role of enzymes:

ATP - the molecule for energy storage

LAB INVESTIGATION

OXIDATION-REDUCTION IN LIVING CELLS

INTRODUCTION:

We are accustomed to thinking of oxidation occurring when iron rusts or wood burns and oxygen is required. In some living cells oxygen may never be involved in reactions of this type. More often it is involved, but only in the last step of many oxidation-reduction reactions that already have occurred without oxygen. Oxidation in living tissues involves loss of electrons of hydrogen atoms, and reduction involves their gain.

In this investigation you will first demonstrate oxidation and reduction in a model, then investigate it in living tissues.

MATERIALS:

- 6 volt battery
- 2 lengths, 40 cm. of insulated single-strand copper bell wire
- U tube, approximately 6 mm in diameter with 8 cm arms
- 2 cork stoppers, No. 000 size
- Dissecting needle
- Living yeast suspension
- 5 percent sucrose solution
- Graduated pipette
- Ring stand
- Clamp
- 6 to 10 ml methylene blue solution (0.01 g methylene blue per 100 ml distilled water, to which 15 drops of concentrated sulfuric acid have been added for each 100 ml) (CAUTION: *The acid must be added very slowly, or it may spatter and cause burns.*)
- 6 to 10 ml of the same methylene blue solution without acid
- 2 test tubes, 18 x 150 mm
- Test tube rack

DIRECTIONS:

Part A. Oxidation-Reduction Model

Even though we cannot see electrons or hydrogen atoms and therefore cannot watch them being moved about, we can investigate their transfer in the laboratory by means of a model. Methylene blue is an indicator that is colored in the oxidized state and colorless in the reduced state.

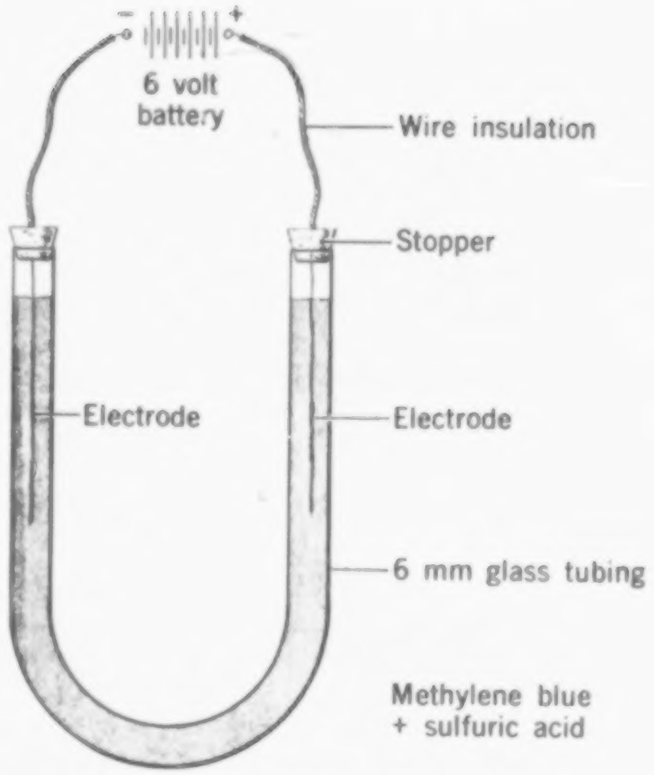
The experimental setup is arranged as in the diagram on the following page. Attach the wires to the battery terminals, and clamp the U tube to the ring stand. Use the pipette to transfer to the U tube the methylene blue solution with sulfuric acid added. Fill the U tube to within about 2 cm of the top. (CAUTION: *DO NOT SPILL ANY OF THE SOLUTION ON YOUR HANDS OR CLOTHING. THE BLUE DYE IS HARD TO REMOVE, AND THE ACID WILL CAUSE BURNS.)*

Clean the insulation from the last 5 to 6 cm of each piece of bell wire. Make a hole in each cork with a dissecting needle or larger instrument and insert the bare end of the wire from the top, running the wire completely through the cork until stopped at the point where the insulation begins. Place the corks loosely in each arm of the U tube. The electrodes (bare copper wires) are now immersed in the solution in the U tube. Note which of the electrodes is positive and which is negative

Observe the U tube carefully for 20 to 30 minutes and record your observations, noting the time at which changes occur.

NOTE: Answer these questions on the Lab Report Sheet which follows.

1. At which electrode do you notice a change?
2. Remembering that you are dealing with oxidation-reduction reactions, what gas is being released?
3. How could you verify your answer to the preceding question?
4. What changes do you note in the methylene blue solution?
5. Compare and record the changes in both arms of the U tube.



Oxidation-reduction by electrolysis

Without removing the wires from the U tube, reverse them on the battery. Go ahead with Part B while waiting for further changes to occur. Then note changes and their times of occurrence.

6. What information does the reversal of the electric current give you about this reaction?

Part B. Oxidation-Reduction in Living Cells

The model in Part A has demonstrated oxidation-reduction without the addition of oxygen.

7. Then what brought about the changes?

Next, you will investigate a similar reaction within a living system. Use a pipette to place 3 ml of methylene blue solution (without acid added) in each of two test tubes. Add some living yeast suspension in 5 percent sucrose solution, to within about 3 cm of the top of the tube. To the other tube, add yeast suspension prepared identically but boiled before use.

8. What is the purpose of this second tube?

Set both tubes in the test tube rack and observe during a period of 20 or 30 minutes. Record your observations. If no results are noted during this time, continue to observe the tubes for a longer span of time. Come in after school or wait until the next day if this should be necessary.

9. How do you explain the changes that occur in the two test tubes?

Compare these changes with the changes earlier noted, and those now evident with the reversal of electrodes, in the U tube model. (As a part of your comparisons, note that the methylene blue solution in the two test tubes was diluted by the yeast suspension in the sucrose solution.)

10. How can you account for differences in color at different levels within a tube?

Now shake both test tubes and describe what happens.

11. How do you account for the changes you see in the tubes?

12. Summarize your observations by comparing and contrasting oxidation and reduction of the methylene blue solutions in the U tube model and in the test tubes containing yeast cells.

LAB REPORT SHEET

Name ______________________

Science IIA Hour ____

Date ______________________

OXIDATION-REDUCTION IN LIVING CELLS

PURPOSE: Part A. ______________________

Part B. ______________________

PROCEDURE: Part A. ______________________

Part B. ______________________

OBSERVATIONS: Part A. ______________________

Part B. ______________________

CONCLUSIONS: Part A. ______________________

Part B. ______________________

QUESTIONS:

1. ______________________

37

2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________

7. ____________________

8. ____________________

9. ____________________

10. ____________________

11. ____________________

12. ____________________

ENERGY RELEASING PROCESSES

Respiration

Required Reading:	BSCS Blue Version, Ch. 9, pp 199-203 BSCS Yellow Version, Ch. 9, pp 115-123

I. Sources of Energy for Living Cells

II. Methods of Energy Extraction by Living Cells

A. Respiration

B. Fermentation

III. The Process of Aerobic Respiration

A. Nature of the Process in General

B. Location in the Cell

RESPIRATION, Continued

C. The Importance of Enzymes

IV. The Biochemistry of the Reactions Involved in Respiration

A. The Overall Reaction

1. starting substances + conditions

2. substances involved in the reactions

3. energy production

B. Specific Nature of the Reaction

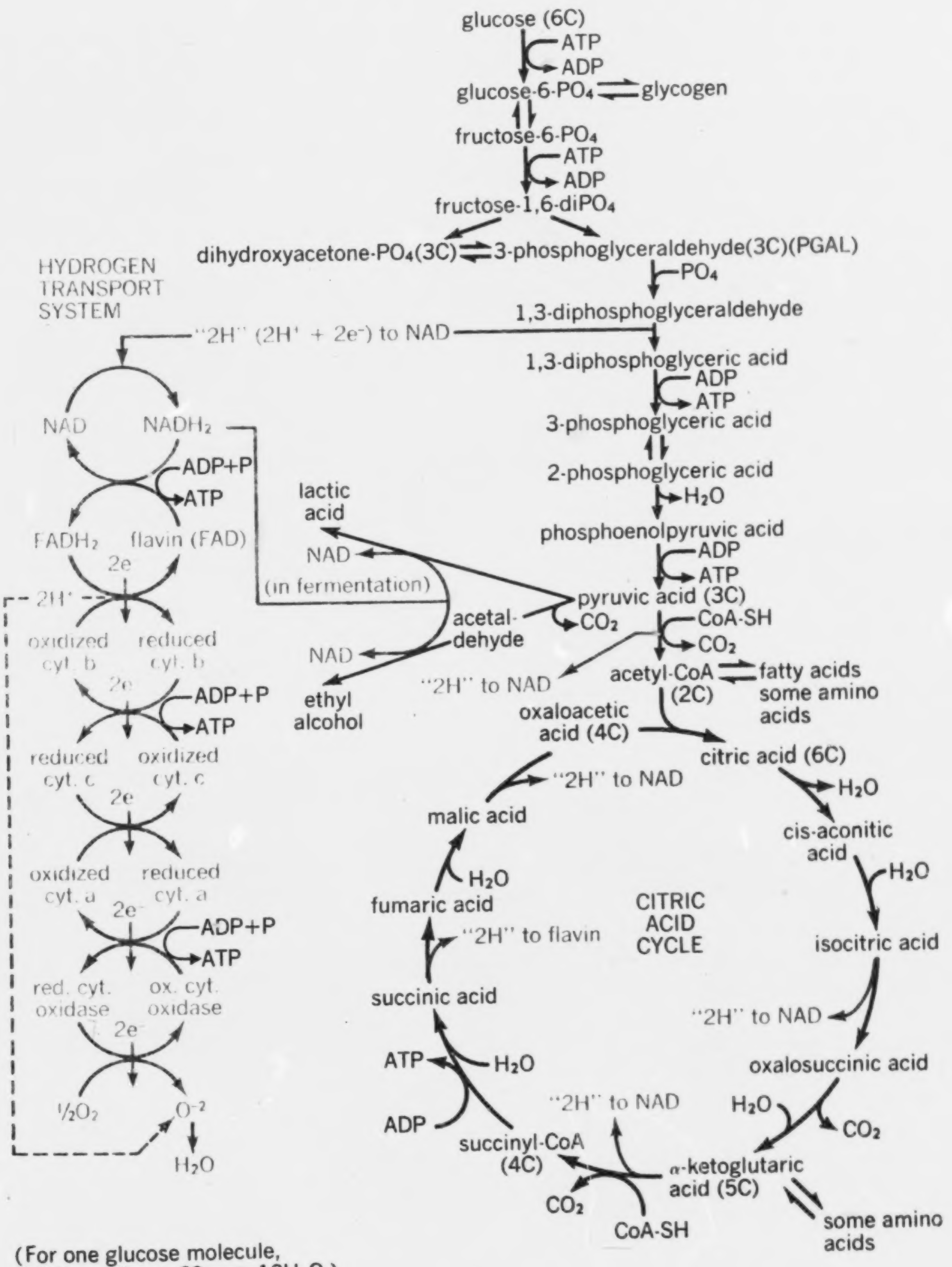
1. Activation Phase

2. Breakdown Phase

3. Energy Production Phase

the Krebs' Cycle

A CONDENSED DIAGRAM OF THE BREAKDOWN OF GLUCOSE


glucose (6C)
ATP
ADP
glucose-6-PO$_4$
glycogen
fructose-6-PO$_4$
ATP
ADP
fructose-1,6-diPO$_4$
dihydroxyacetone-PO$_4$(3C)
3-phosphoglyceraldehyde(3C)(PGAL)
PO$_4$
1,3-diphosphoglyceraldehyde
HYDROGEN TRANSPORT SYSTEM
"2H" (2H$^+$ + 2e$^-$) to NAD
1,3-diphosphoglyceric acid
ADP
ATP
3-phosphoglyceric acid
2-phosphoglyceric acid
H$_2$O
phosphoenolpyruvic acid
ADP
ATP
pyruvic acid (3C)
CoA-SH
CO$_2$
lactic acid
NAD
(in fermentation)
acetal-dehyde
CO$_2$
NAD
ethyl alcohol
"2H" to NAD
acetyl-CoA (2C)
fatty acids
some amino acids
oxaloacetic acid (4C)
citric acid (6C)
H$_2$O
cis-aconitic acid
H$_2$O
isocitric acid
"2H" to NAD
oxalosuccinic acid
H$_2$O
CO$_2$
α-ketoglutaric acid (5C)
some amino acids
CoA-SH
CO$_2$
"2H" to NAD
succinyl-CoA (4C)
ADP
ATP
H$_2$O
succinic acid
"2H" to flavin
fumaric acid
H$_2$O
malic acid
"2H" to NAD
CITRIC ACID CYCLE
NAD
NADH$_2$
ADP+P
ATP
FADH$_2$
flavin (FAD)
2e
2H$^+$
oxidized cyt. b
reduced cyt. b
2e
ADP+P
ATP
reduced cyt. c
oxidized cyt. c
2e
oxidized cyt. a
reduced cyt. a
2e$^-$
ADP+P
ATP
red. cyt. oxidase
ox. cyt. oxidase
2e$^-$
½O$_2$
O^{-2}
H$_2$O

(For one glucose molecule, $24H^+ + 24e^- + 6O_2 \longrightarrow 12H_2O$.)

ENERGY RELEASING PROCESSES

The Mitochondria

INTRODUCTION:

You are studying the very complex process of cell respiration by which the cell extracts its energy from glucose. You should recall that the glucose reaches the cells' mitochondria via the circulatory system, which picks up glucose from digested food in the small intestine. The sub-cellular structure or organelle which actually removes the energy from glucose via cell respiration is the mitochondrion, an organized battery of enzymes.

The structure of the mitochondrion was not fully understood until this century with the full development of the electron microscope. In this lab exercise you will extract mitochondria from live cells - of course they will not be visible to you - and run a brief test to check on the mitochondrial activity.

MATERIALS:

blendor	fresh liver tissue
ice	glass tubing
limewater	stoppered large gas bottles with hole in stopper

DIRECTIONS:

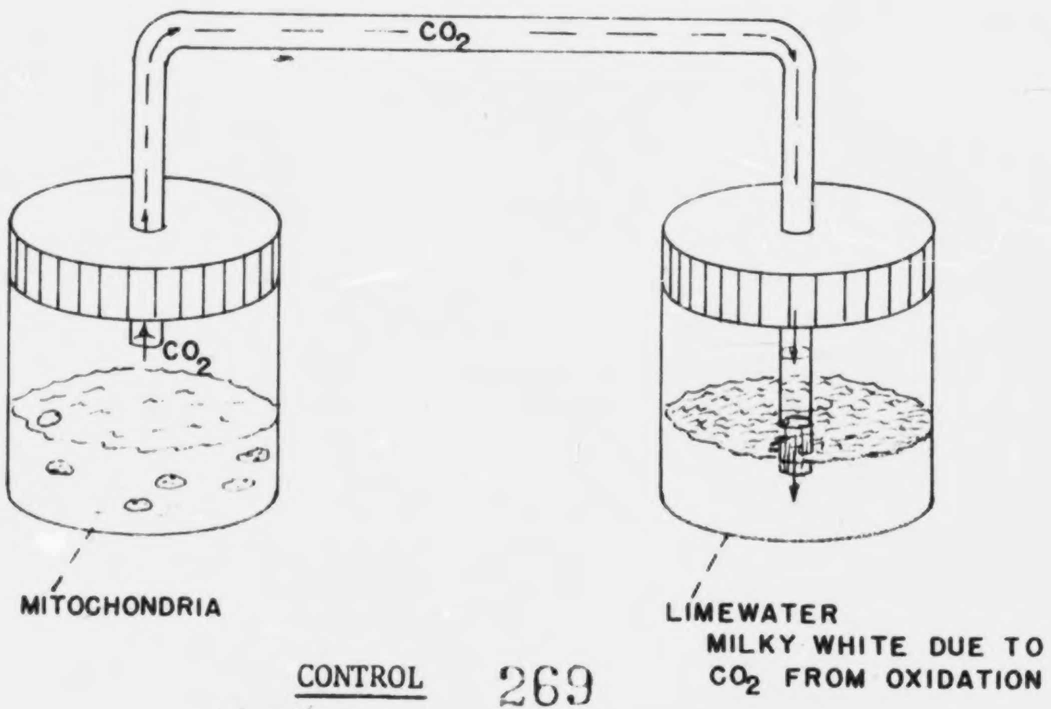
The class will be divided into several groups. Each group will weigh out 10 g. fresh liver. Place the liver in .25 molar sucrose and always keep it cool. This tissue is rich in mitochondria (as many as 1,000 per cell). To separate the mitochondria from the rest of the tissues (technique according to Hogeboom and Schneider):

First, homogenize the tissue at 70 revolutions per minute, using blendor. Add 2 ice cubes before blending.

Second, centrifuge the supernatant fluid at 700xg. The precipitate will contain connective tissue, unruptured red blood cells, and nuclei.

Third, recentrifuge the supernatant fluid at 7,000xg. The precipitate will contain mitochondria and ribosomes. This is as far as one can go in a high school lab. To separate the mitochondria from the ribosomes it is necessary to recentrifuge at 100,000xg.

To show the action of mitochondria, take the mitochondria fraction and place it in the setup pictured. All the other material should be set up in the same way to act as a control.



ENERGY RELEASING PROCESSES

Fermentation

Required Reading: BSCS Blue Version, Ch. 6, pp 115-118

Recommended Reading *Unresting Cells*, R. W. Gerard, pp 127-130

I. Fermentation - a simple energy releasing process

   A. Definition

   B. The Site of Reaction

   C. The Role of Enzymes

II. History

   A. Leibig and Pasteur - the question of whether fermentation was chemical or biological in nature

   B. Buchner and Harden-young

   C. The Caris

FERMENTATION, Continued

III. The Reactions of Fermentation

A. The General Nature of Fermentation

1. starting substance & conditions

2. energy production

B. The Specific Nature of Fermentation

1. Activation Phase

2. Breakdown and Energy Production Phase

3. End Products

ENERGY RELEASING PROCESSES

Fermentation

An Investigation of Energy Production

INTRODUCTION:

Many exciting and stimulating science experiments for the classroom laboratory can be based on procedures used in the discovery of fundamental scientific principles, such as energy production.

The mechanisms by which living organisms produce energy have captured the imagination and attention of some of the most famous men of science. Men like Priestley, Lavoisier, Pasteur, Büchner, Thunberg, Szent-Györgyi, Krebs, Lehninger, Green, and Chance--to mention a few--have spent a great share of their professional lives studying this problem. The main threads of their work are not too difficult to recapitulate and follow in the laboratory.

Near the end of the 18th century Antoine Lavoisier discovered that the fermentation of glucose produced alcohol and carbon dioxide. In *"Etudes sur la bière,"* published in 1876, Louis Pasteur described the inhibition of fermentation by an aerobic environment. He noted that, although yeast cells were able to grow under anaerobic conditions with the production of alcohol and carbon dioxide, they could grow more efficiently in the presence of oxygen, but the production of alcohol was depressed. In this way a relationship between the intermediates of fermentation and aerobic processes was established, although the implications of this discovery were not understood at the time. In fact, it was not until 1897 that Buchner, in a series of experiments, implicated yeast extracts or enzymes in the fermentative process.

In 1920, Thunberg pointed out the importance of hydrogen transfer, through the mediation of an enzyme, in the reactions of energy production. He noted that the striated muscle of a freshly killed frog lost its power to decolorize methylene blue when the muscle was extracted with water. The ability was restored when succinic acid was added to the system. Thunberg concluded that two hydrogen atoms had been transferred from succinic acid to methylene blue, yielding the leuco compound of methylene blue. He further noted that other compounds such as lactic, fumaric, α- and β- hydroxybutyric and malic acids all gave reactivating results. On the basis of these observations, he deduced that simple compounds such as glucose, fat, and amino acids pass through a series of dehydrogenation steps, combined in certain cases with hydrolysis, or with CO_2 splitting, before final disposal. The hydrogen removed from these compounds finally unites with oxygen to form water. This hypothesis was the basis for the suggestion of a dicarboxylic acid or Kreb's cycle functioning as an energy producer.

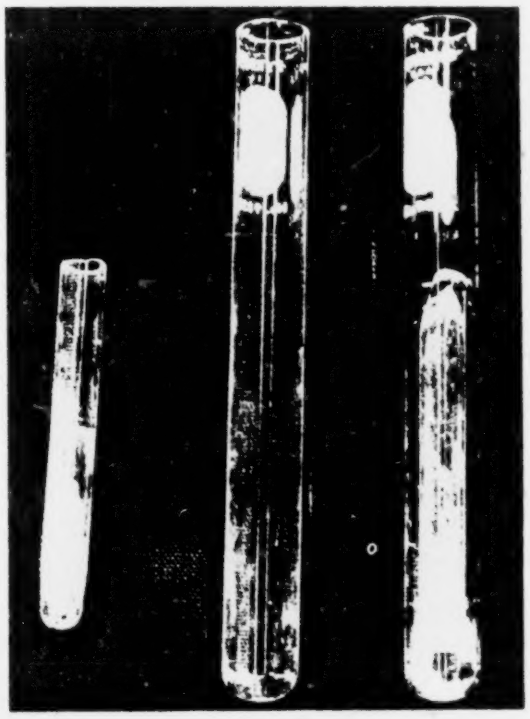
The stimulatory effect of the dicarboxylic acids on respiration, demonstrated by Szent-Gyorgyi in 1936, laid the groundwork for the billiant piece of experimentation and deduction by Krebs in the formulation of the tricarboxylic acid cycle. Since then, the characteristics of the energy-producing systems have been intensively studied, but are still not well understood.

PROCEDURE:

Part I. *Fermentation*

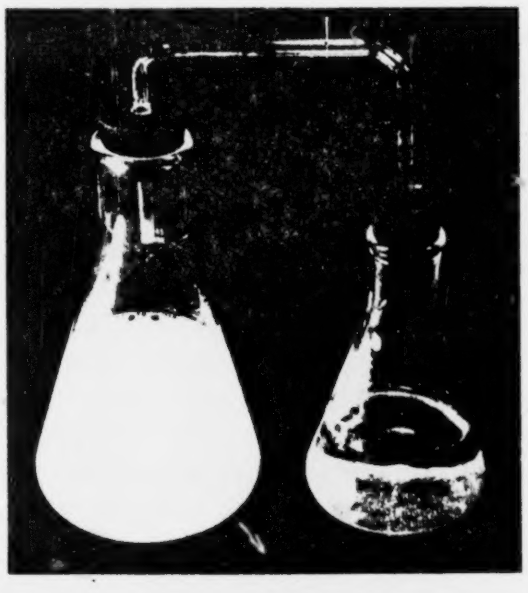
The fermentation of glucose by a yeast suspension may be studied using fermentation tubes made from 10- and 16-mm test tubes. Combine 15 ml of a yeast suspension (10 grams of cake yeast and 1 gram of glucose dissolved in 0.1 M sodium phosphate buffer, pH 7.0) with an equal volume of 5 percent glucose solution. (To make the phosphate buffer solution, mix 390 ml of 0.1 M NaH_2PO_4 solution with 610 ml of 0.1 M Na_2HPO_4 solution. Check the pH with the pH meter.)

Ten milliliters of this mixture are added to each of three larger, outer test tubes. One tube is placed in a boiling water bath for five minutes, then cooled to room temperature. The second tube is placed in ice water, and the third tube is left at room temperature. Each of the smaller tubes is now filled with the yeast-sugar mixture from the larger tube into which it will be placed, then inverted into the partially filled outside tube. The tubes are observed at various time points and the amount of gas produced is recorded.



Demonstration of fermentation. The small test tube is filled with yeast-sugar solution and inverted into a larger partially filled tube. The amount of gas produced is recorded.

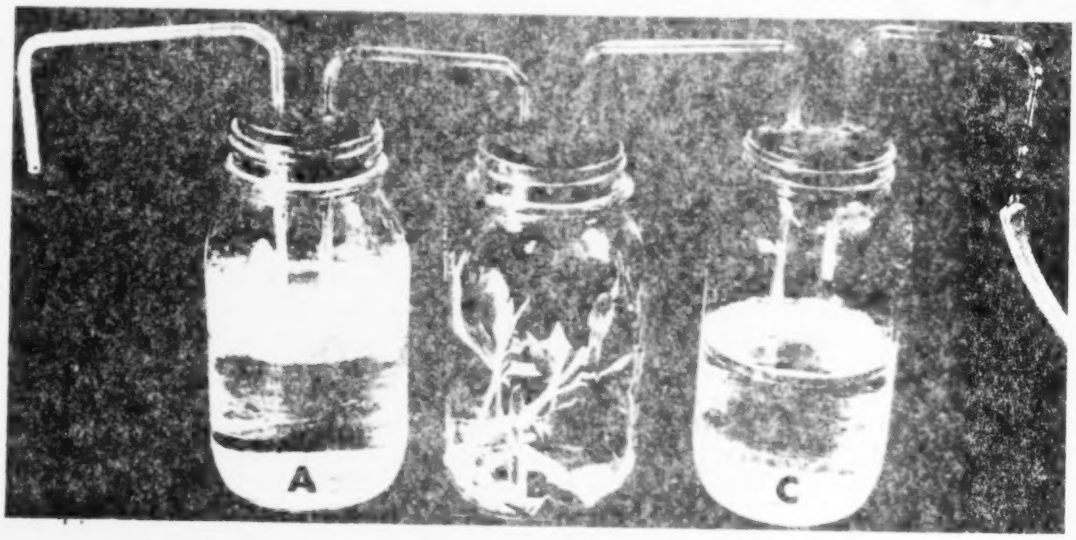
The nature of the gas produced is identified by passing it into a saturated solution of barium hydroxide which has been filtered just prior to class time. This is best accomplished as a demonstration. The larger flask is filled with the same type of yeast-sugar mixture used in the fermentation tubes, and the smaller flask contains the $Ba(OH)_2$ solution. The gas evolved is led from the fermentation flask to the flask containing the $Ba(OH)_2$ through glass and rubber tubing. The appearance of a precipitate ($BaCO_3$) indicates that CO_2 is, indeed, the waste product of fermentation.



The gas is identified by passing it into a solution of barium hydroxide.

Part II. *Aerobic Energy-producing Processes - Respiration*

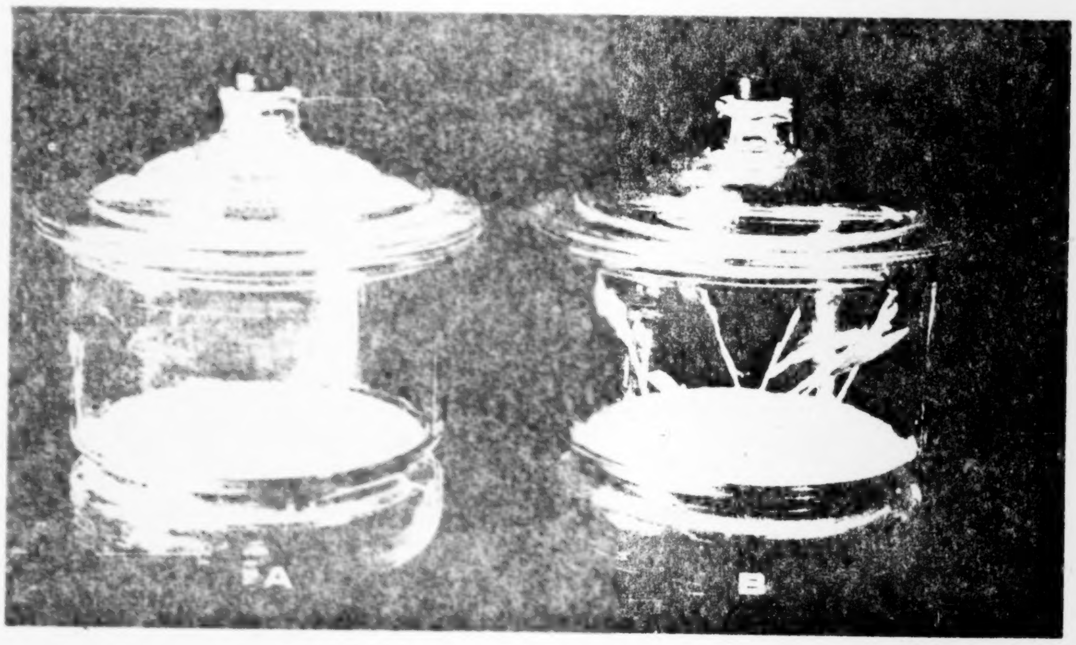
In this phase of the laboratory investigation on energy production, you will study cellular respiration. You will note the production of CO_2 by observing the formation of a precipitate when the gas produced by germinating seedlings is passed into a solution of $Ba(OH)_2$.



Demonstrating carbon dioxide production. Bottle A contains potassium hydroxide solution which removes CO_2 from the air; B contains germinating corn seeds; and C, barium hydroxide. Bottle C is connected to an aspirator.

Germinating corn seeds are placed in the center bottle, which is sealed and connected to the other bottles with glass and rubber tubing. The air is drawn through the apparatus by means of an aspirator attached to the final exit tube. The CO_2 is removed from the air by a concentrated potassium hydroxide solution in the first bottle so that any precipitate formed in the last bottle must have been the result of the CO_2 released by the seedlings.

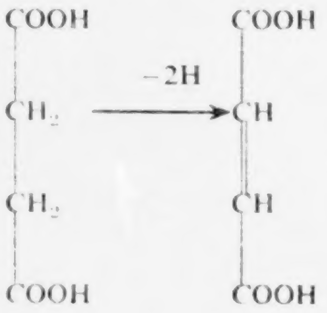
The need for oxygen is established by comparing seeds germinating in the absence of oxygen with seeds in the presence of oxygen. A week before the laboratory period several kernels of corn are soaked for 24 hours in water and placed in an airtight container above a solution of alkaline potassium pyrogallate, a substance which absorbs oxygen. The remainder of the seeds are placed in a similar container except that the pyrogallate solution is replaced by water. The students note the extent to which seeds in each container have germinated.



The importance of oxygen to respiration. In container A, corn kernels have been placed above a solution of alkaline potassium pyrogallate, a substance which absorbs oxygen. B contains corn kernels that are germinating above water.

Hydrogen transfer by Krebs cycle intermediates: Either before or at the beginning of the laboratory period, a homogenate is prepared from a fresh cold beef heart in the following manner: Approximately 100 grams of cold beef heart muscle, from which the fat and connective tissue have been removed, is ground in a cold meat grinder and washed three times with ice-cold distilled water in a 1-liter beaker. After the final rinse solution has been decanted from the hash, it is dried further by placing it on filter paper in a Buchner funnel and removing the remaining water by suction. The hash is then pressed dry with a clean flat object, such as the bottom of a beaker. The dried minced tissue is transferred to a Waring blender, combined with 350 ml of 0.1 M phosphate buffer, pH 7.4 and homogenized for 2 minutes. (To prepare the 0.1 M buffer, mix 53 ml of a 0.1 M monobasic potassium phosphate (KH_2PO_4) solution with 947 ml of 0.1 M dibasic potassium phosphate (K_2HPO_4) solution. Check the pH with a pH meter.) The suspension is passed through cheesecloth in a funnel to remove any large particles. This cloudy suspension contains succinic dehydrogenase, an enzyme of the tricarboxylic acid cycle, and is now ready for use. Although the homogenate is relatively stable when frozen, it should not be stored for more than one or two weeks if maximum activity is desired. All steps in the preparation of the homogenate must be conducted at 0°C to 4°C.

In this experiment, methylene blue serves as the hydrogen acceptor, and succinic acid is converted into fumaric acid:



$$COOH-CH_2-CH_2-COOH \xrightarrow{-2H} COOH-CH=CH-COOH$$

(Under normal cellular conditions the H acceptor is FAD.)

The end point of the reaction is indicated by the disappearance of the blue color of the methylene blue.

Eight test tubes are labeled from 1 through 8. One milliliter of 0.01 percent methylene blue solution and 2.0 ml of 0.1 M phosphate buffer, pH 7.4, are added to each tube; 2.0 ml of 0.1 M sodium succinate is added to all but the first tube. Distilled water is now added to the tubes in the amounts indicated in the following Table.

Enzymatic Oxidation of Sodium Succinate

TUBE No.	DISTILLED WATER	HEART HOMOGENATE	TIME TO DECOLORIZE
	ml	*ml*	
1	5.0	2.0	—
2	5.0	0	—
3	4.5	0.5	—
4	4.0	1.0	—
5	3.5	1.5	—
6	3.0	2.0	—
7	3.0	2.0 (boiled)	—
8	3.0	2.0	—

The tubes are cooled in an ice bath, and then the indicated amounts of homogenate are added to each tube. Beef heart homogenate which has been boiled for 3 minutes is added to tube 7. After mixing, the first 7 tubes are placed in a water bath at 37°C. Tube 8 is left in the ice-water bath for the duration of the experiment. The time it takes for each tube to decolorize is recorded. The student is cautioned *not to agitate* the tubes during this experiment since methylene blue is easily reoxidized. The student now plots the time for the solution to decolorize against the amount of homogenate used. This gives a plot of the velocity of the reaction versus the concentration of the enzyme.

ENERGY RELEASING PROCESSES

The Effect of pH on Enzyme Activity

(Source - Science Teachers Workshop, June 1970)

INTRODUCTION:

In studying the processes of aerobic respiration and fermentation we must remain aware that each step of these complex reactions is controlled by enzymes. Enzymes are protein and therefore most sensitive to changes in their surroundings.

This lab is designed to demonstrate the effect of pH on enzyme activity using the enzyme catalase, an enzyme common to most cells and found in large amounts in liver cells. Catalase acts on hydrogen peroxide, causing the following reaction to occur:

$$2H_2O_2 \quad \text{catalase} \quad 2\ H_2O + O_2$$

The O_2 will cause bubbles if the reaction occurs rapidly. The rate of reaction can thus be measured by the amount of O_2 given off during a given time period.

MATERIALS:

To complete the exercise, each student or team will need:

10 test tubes (15 x 125 mm.)
large test tube
test tube rack
small beaker
glass stirring rod
3 medicine droppers
millimeter ruler

50 ml 3% H_2O_2
10 ml. 0.1 M NaOH
10 ml. 0.1 M HCl
Distilled water
fresh liver (beef, chicken, frog, etc.) a piece the size of a bouillon cube

PROCEDURE:

Directions for performing the exercise are as follows:

Enzyme Preparation

1. Place a small piece of liver in approximately 5-10 ml. of distilled water in a large test tube.
2. Shred the liver with a glass rod until the water becomes turbid (3 to 5 minutes)
3. Pour the liquid containing catalase (and other enzymes which will not break down H_2O_2) into a clean beaker. (If more enzyme is desired, repeat steps 1-3 using the same piece of liver.)

NOTE: Students should understand that many enzymes are involved here but that only one works on the hydrogen peroxide.

Familiarization with Reaction

4. Place 5 ml. of 3% H_2O_2 in a 15 x 125 mm. test tube.

IMPORTANT: All glassware must be well cleaned prior to use.

5. Place 2 drops of enzyme solution in the H_2O_2.

6. Note the reaction. After it has slowed (about 30 seconds), measure the height of the bubble column.

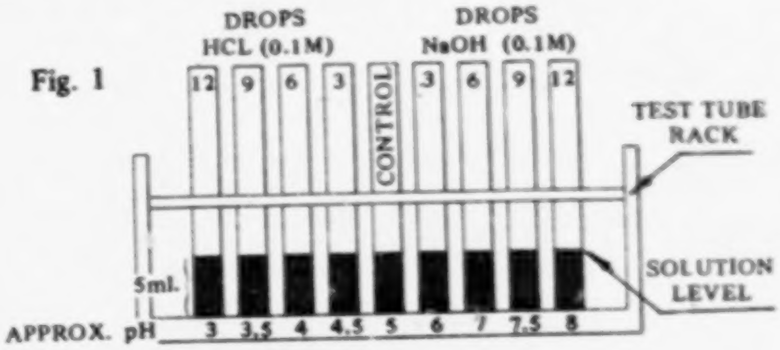
Effect of pH

7. Place 5 ml. of 3% H_2O_2 in each of the remaining 15 x 125 mm. test tubes.

NOTE: Test tube sizes and amounts are not critical as long as they are constant. Variations may be made to fit available materials.

8. Label the center tube as the control. Place 0.1 M NaOH or 0.1 M HCl in the remaining tubes as indicated in Fig. 1. (This will give a pH range of approximately pH 3 to pH 8.)

Fig. 1


DROPS
HCL (0.1M)
DROPS
NaOH (0.1M)
12
9
6
3
CONTROL
3
6
9
12
TEST TUBE RACK
5ml.
SOLUTION LEVEL
APPROX. pH
3
3.5
4
4.5
5
6
7
7.5
8

VARIATION: The acid and base may be of different concentration and amounts may be varied. The teacher should experiment with different combinations before student use.

9. Add 2 drops of enzyme solution to each tube. Measure the height of the column as previously practiced.

10. Graph your results (Fig. 2).

FURTHER USES:

This lab can readily be adapted to show the effects of temperature, dilution, and other influences upon enzymatic activity.

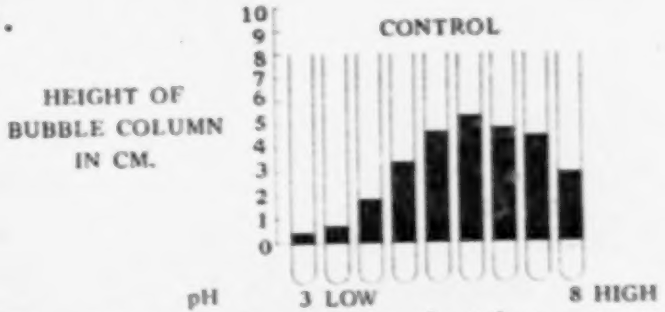


Fig. 2: Effect of pH on action of catalase.

BIOSYNTHESIS - ENERGY UTILIZATION

DNA and RNA Synthesis

Recommended Reading: Scientific American, Oct. 1968, "The Synthesis of DNA"

I. The Dual Function of Nucleic Acids

II. The Source of Energy for all Synthesis Reactions

III. Review of the Structure of DNA and RNA

   A. Sugars

   B. Phosphates

   C. Bases - purines and pyrimidines

IV. DNA's Code

   A. Matching DNA Bases with Amino acids

   B. DNA Code Triplets

V. DNA and RNA

  A. Types of RNA

  B. How DNA and RNA differ

    1. sugars

    2. Uracil-thymine substitution

    3. Double Strand vs. Single Strand

  C. Synthesis of RNA by DNA

  D. Kinds of RNA

    1. Messenger RNA

    2. Transfer RNA

BIOSYNTHESIS - ENERGY UTILIZATION

Protein Synthesis

Required Reading: BSCS Yellow Version, pp 170-173 and pp 759-760

II. Protein Synthesis

A. The Role of DNA

1. The Production of M - RNA

2. Significance of the "triplet"

B. The Role of Messenger RNA

C. The Ribosomes

1. Their Location in the Cell

2. Their interaction with the Nucleic Acids

D. The Role of Transfer RNA

1. The Amino Acids Involved

2. The Place of ATP

E. The Synthesis Reaction

1. Joining Amino Acids by Dehydration

2. The significance of the Proteins Formed

III. Synthesis of Other Molecules

A. Fats

B. Pigments

THE BASIS FOR EXCHANGE OF MATTER BETWEEN ORGANISMS AND THEIR ENVIRONMENT

I. Continuity of Fluids Between Organisms and their Environment

A. Cells and organisms as open systems

B. Forms of matter essential for life that are provided by the environment

C. Forms of matter that are toxic by-products of life functions and must be eliminated into the environment

II. Two Basic Mechanisms of Transport Between Organism and Environment

A. passive transport

1. defined

2. pores in the cell membrane

3. kinetics of passive transport

4. consequences of uncontrolled passive transport

a. forces involved

b. ways of measuring osmotic pressure

c. work-energy relationships

B. Active transport

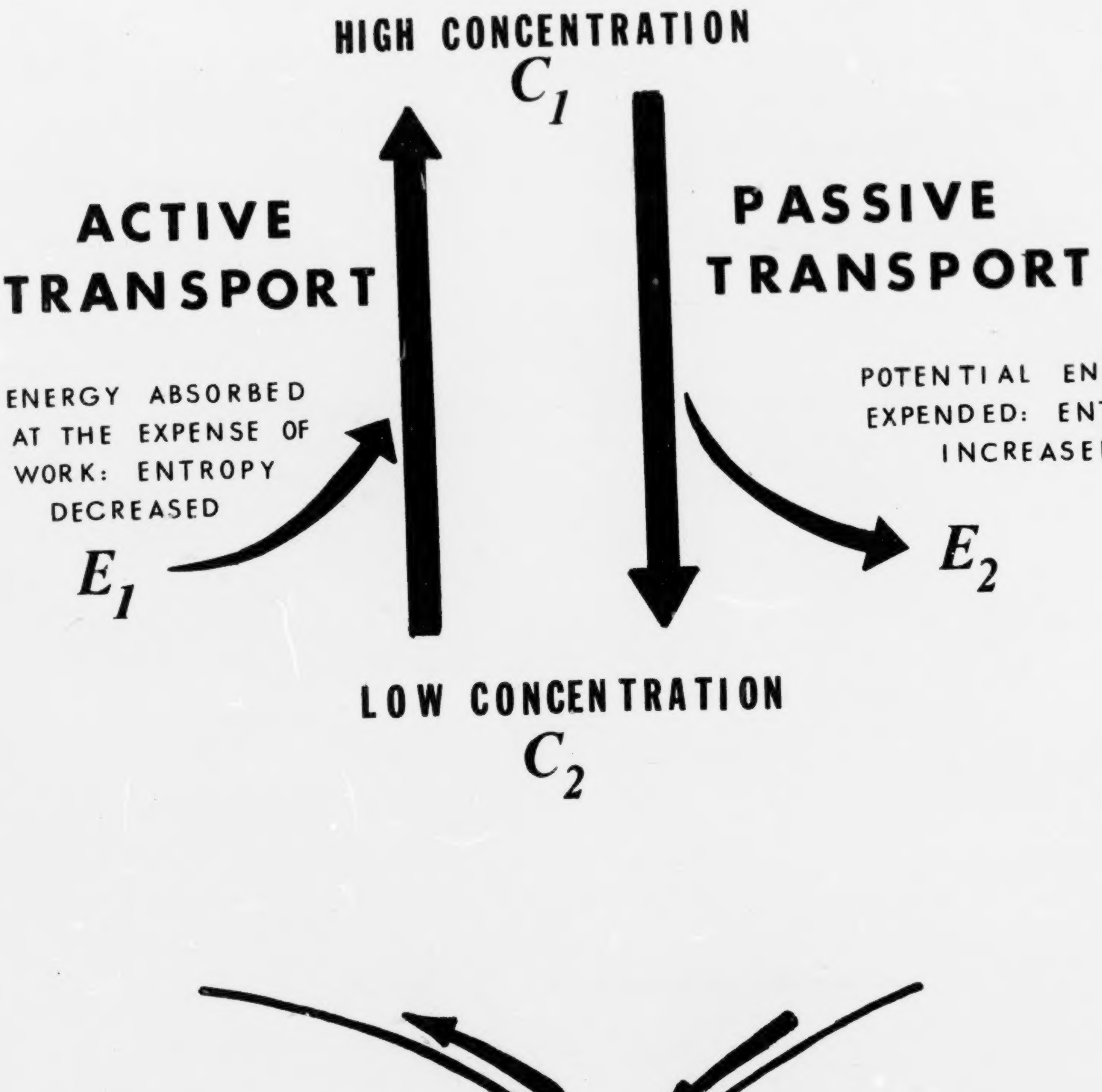
1. active transport defined

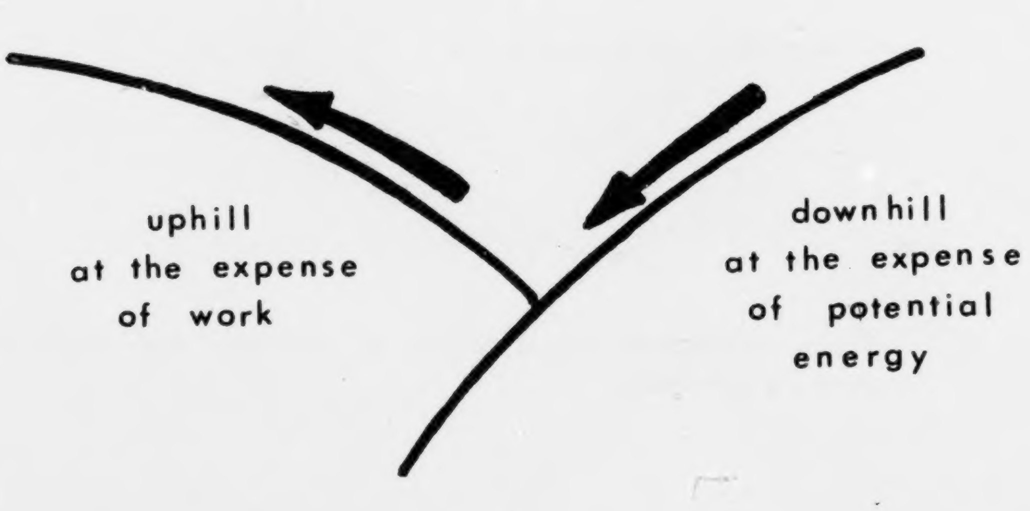
2. role of the cell membrane in active transport

3. role of mitochondria and ATP

4. work-energy relationships

5. active transport as a means of control and regulation of osmotic pressure


HIGH CONCENTRATION
C_1
ACTIVE TRANSPORT
PASSIVE TRANSPORT
ENERGY ABSORBED AT THE EXPENSE OF WORK: ENTROPY DECREASED
E_1
POTENTIAL ENERGY EXPENDED: ENTROPY INCREASED
E_2
LOW CONCENTRATION
C_2


uphill at the expense of work
downhill at the expense of potential energy

BASIS FOR THE TRANSPORT OF MATTER WITHIN ORGANISMS AND THEIR ENVIRONMENT

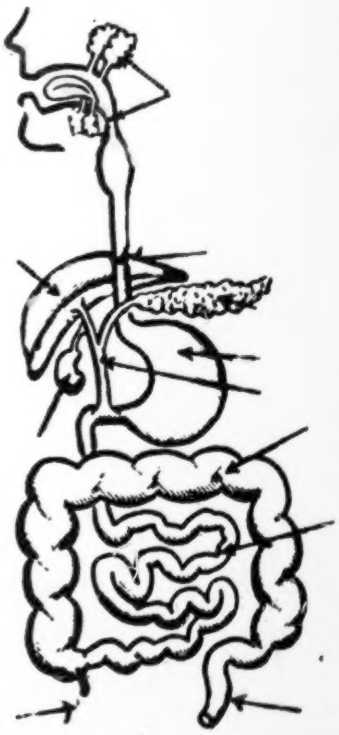
Systems Involved in the Transport of Matter

I. The Living Organism is Constantly Exchanging Matter with its Environment

II. Specialized Systems Within the Living Organism

A. The Digestive System - A Review

The Structures:



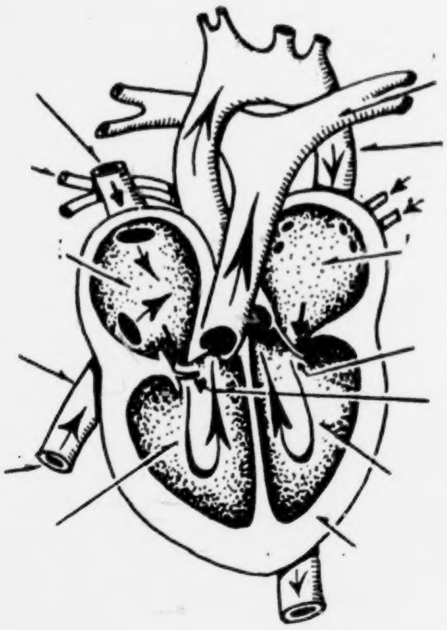
The human digestive system.

The Functions:

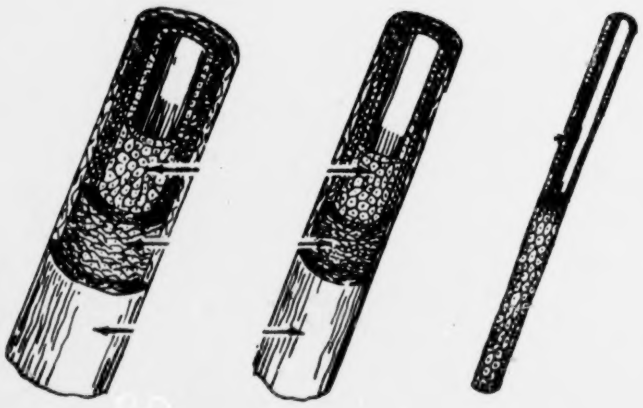
B. The Circulatory System

The Structures:

The Heart



The Blood Vessels

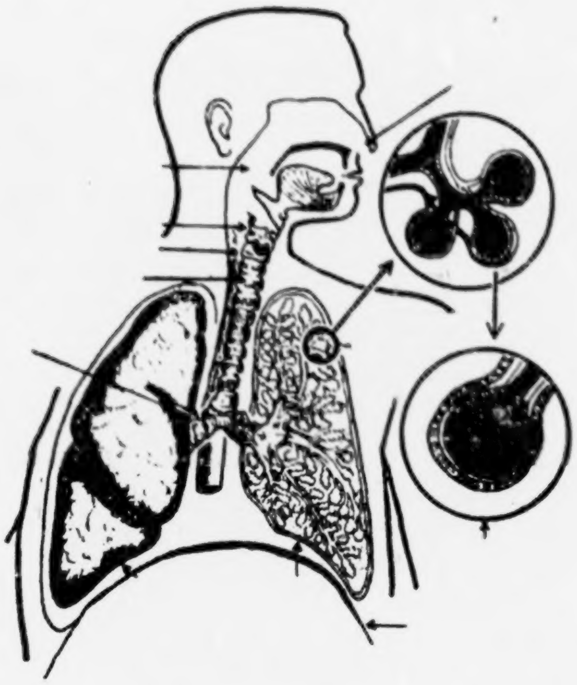


The Blood

The Functions

C. The Respiratory System

The Structures:

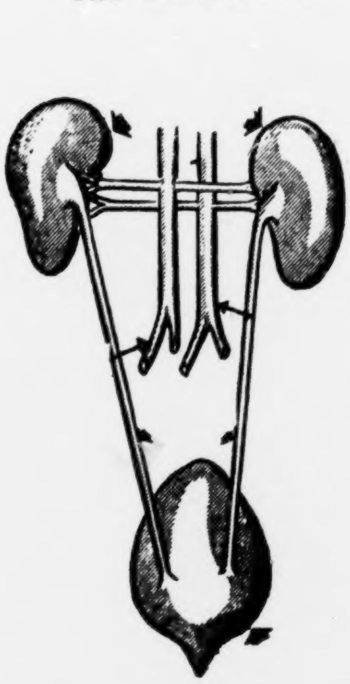


The Functions

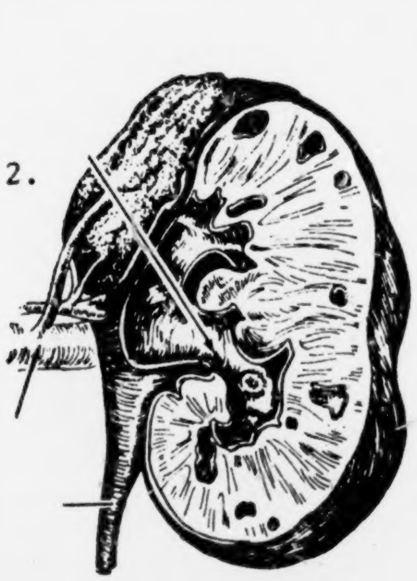
D. The Excretory System

The Structures

1.

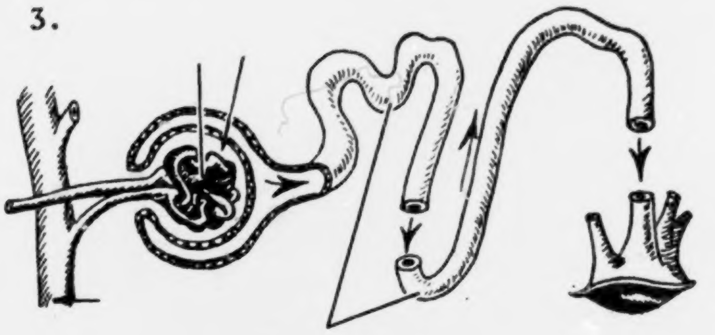


2.



A cross-section of the kidney.

3.



Nephron tubules.

III. Interrelationships Among Systems

THE EARTHWORM - A REPRESENTATIVE ANNELID

PURPOSE:

To study the anatomy of the earthworm.

PROCEDURE:

External Structure of the Earthworm: Examine your specimen carefully. Rub your fingers over the surface. (1) - Describe the body covering. The bristles on the body surface are called setae. (2) - How many are there on each segment? (3)— Where are they attached? (4)—How do they function in locomotion? (5)— Determine whether the animal has a definite anterior and posterior end and explain your answer. Locate the mouth and the anus. Locate the prostonium above the mouth. Use a hand lens or stereoscopic microscope to locate the excretory pores. (6)— How may are there on each segment? (7)—What is the function of the excretory pore? Examine segment 14 and locate the female pore, through which eggs leave the body. Locate the male pore on segment 15. Sperm leave the body through this opening. Locate the openings on segments 9-10 through which sperm enter the worm. Examine the thickened area encircling the body. This is the clitellum, or girdle. (8)-What is its function?

Internal Structure of the Earthworm: Using a preserved earthworm, observe the following instructions in your dissection of the animal:

1. Read the instructions carefully before you begin to cut.
2. Identify structures to be cut before cutting.
3. Lift the structures to be cut.
4. Cut only when directed to do so.
5. When possible use your fingers instead of a needle to expose structures.
6. Before you begin be sure you understand the meaning of the following terms: anterior, posterior, dorsal, ventral, median, longitudinal.

Put the specimen in a dissecting pan with the dorsal side up. Pin the anterior and posterior parts to the pan, using care not to put the pins through any internal organs. Use your scissors to cut through the body wall slightly to the left of the mid-dorsal line. Begin about an inch behind the clitellum and extend the cut to the mouth. Be careful not to cut through anything but the body wall. Separate the edges of the cut and look into the body cavity. Observe that the body wall is separated from the intestine (the long brown structure) by a definite space called the coelom. Notice that in the coelom there are septa (partitions) extending from the body wall to the intestine. Using forceps and needles, carefully cut the septa, segment by segment, until the anterior end of the worm is entirely open for study. Pin down the side of the body wall as you cut.

A. Muscular System: Locomation in an earthworm is accomplished by two sets of opposing muscles. The circular muscles lying just beneath the body wall, forms rings parallel to the circumference of the worm. When these muscles contract, the segments are constricted, causing the worm to lengthen. Another muscle layer, the longitudinal muscles, lie just beneath the circular layer. These muscles lie parallel to the length of the worm. When the longitudinal muscles contract the body shortens, causing the segments to thicken. If portions of the worm are anchored by setae, the unanchored portions move toward the anchored region. (9)- Explain how the worm moves if the anterior end is anchored.

* B. Digestive System: This system is composed of a tube extending from the mouth to the anus. This digestive tract has specialized areas which you will observe and include in your diagram. The buccal cavity is a small tube which passes from the mouth to about the third segment. The pharynx is the thick-walled area posterior to the buccal cavity. (10)- What is the purpose of thick walls? (11)- What is the function of the pharynx? The esophagus is a long, slender tube extending from behind the pharnyx to segment 15. (12)- What function does the esophagus serve? The crop is the large and thin-walled area posterior to the esophagus. (13)- What is its function? The gizzard is the thick-walled area posterior to the crop. (14)- What action occurs in this structure? You have already identified the intestine, which extends from the gizzard to the anus. Sketch this system on your lab report sheet which follows. Label all parts.

* C. Reproductive System: In segments 10, 11, and 12 there are pairs of white structures called seminal vesicles. Sperm are stored in these organs. In segments 9 and 10 there are pairs of small, white spherical structures called seminal receptacles. These organs receive sperm from another earthworm. Under the seminal vesicles you may be able to locate the ovary, in which eggs develop. Sketch this system.

D. Circulatory System: The dorsal blood vessel appears as a dark brownish vessel running along the medial surface of the intestine. In many individuals you can see on the intestinal wall the two pairs of branches which this vessel gives off in each segment. Remove the seminal vesicles from the left side of the body. Look in segment 11 for a pair of stout tubes arising from the dorsal vessel and extending ventrally. These "hearts", or aortic arches, are often discolored because they contain blood. (15)-What is the function of these structures? Now look in each segment from 11 forward to 6 for a similiar pair of tubes. You will have to remove the septa to see these clearly. Use your dissecting needle to push the intestine to the right side to enable you to see the median ventral line. You should then be able to see the brownish ventral blood vessel. Follow this vessel to its connection with the aortic arch. Sketch this system.

E. Excretory System: The coiled white, loose tubes along side of the digestive tract are the excretory organs called nephridia. Use a dissecting scope scope to find them. They are located in each segment except the first three and the last two inches. Open the body wall and pin it back in this area. Carefully pull out the intestine from the body cavity. Observe the nephridia under the dissecting microscope, using your dissecting needle to search them out. (16)-How are the nephridia connected to the outside?

* THESE SYSTEMS ARE TO BE SKETCHED ON THE LAB REPORT SHEET WHICH FOLLOWS.

62 A

* F. Nervous System: In the area of segments 2 and 3, dorsal to the buccal cavity, the "brain" or suprapharyngeal ganglion is located. From this ganglion, the ventral nerve cord extends the length of the animal. Remove part of the intestine and locate the nerve cord. Note the small ganglion at each segment. Cut the nerve cord and pull it free from the body. Now observe the small nerves branching from the ventral nerve cord. (17)- Where do the nerves go? (18)- What is their function? (19)- There is no evidence of a specialized respiratory tract. Explain how oxygen and carbon dioxide are exchanged in the earthworm. Sketch this system

LAB REPORT SHEET

Name ________________________

Science IIA Hour ____

Date ________________________

THE EARTHWORM

Part I.

1. ________________________

2. ________________________

3. ________________________

4. ________________________

5. ________________________

6. ________________________

7. ________________________

8. ________________________

9. ________________________

10. ________________________

11. ________________________

12. ________________________

13. ________________________

14.____

15.____

16.____

17.____

18.____

19.____

Part II. Drawings

1.) Digestive System

2.) Reproductive System

3.) Circulatory System

4.) Nervous System

BASIS FOR THE TRANSPORT OF MATTER WITHIN THE ORGANISM

Interrelationships Among Systems

INTRODUCTION:

You have recently observed in some detail the systems of the earthworm and the frog including the systems which transport matter. You have observed in your dissections that all of the systems are constructed to coordinate their actions and to work together. The major systems of transport we have been concerned with are the digestive, circulatory, respiratory and excretory systems. These systems are all designed for the transport of matter and specifically for transport of matter to the cells.

Keeping this in mind think back to the structure of these systems and then answer the following questions which will later be discussed by the class.

QUESTIONS CONCERNING THE INTERRELATIONSHIPS AMONG SYSTEMS.

Part I.

1.) The digestive system and the circulatory system are directly in contact in a certain structure in the body. Where is this? Describe how the systems are in contact.

2) At the point of contact (in #1) the circulatory system picks up a substance from the digestive system. What is this substance?

3) The circulatory system carries oxygen linked to the hemoglobin molecules of the red blood cells. Where and how do the red blood cells acquire this oxygen?

4) Where do the red blood cells deliver their oxygen?

5) The excretory system is directly connected to the circulatory system in the glomerulus of the kidney. What is the result of the blood's passage through the kidney?

Part II. Essay

The digestive system and the respiratory system are not structurally connected but they do work together in performing a common function. (1) Describe the major structures of these two systems, (2) tell in detail what their major functions are and (3) describe how these two systems provide necessary materials to all the cells. Most importantly, (4) describe the cellular process that these two systems sustain and (5) any cell structures which might be involved.

THE CONTINUITY OF FLUIDS AS MEDIA FOR TRANSPORT AND EXCHANGE THROUGHOUT THE ENTIRE GLOBAL ENVIRONMENT

I. Naturally-occurring fluids and their global distribution

A. molten magmas

B. crude oil

C. water

1.

2.

3.

4.

D. fluids within the bodies of plants and animals: "portable oceans of life"

E. gases and solids as fluids

II. Physical-Chemical Interactions which Establish the Basis for the Continuity of Fluids

A. physical and chemical interactions involving water

1. vulcanism

2. erosion (solubility of rocks and minerals)

3. formation of acid anydrides (gaseous) through oxidative processes

4. water-pollution

5. evaporation and precipitation

6. heat exchange

7. water-exchange between organisms and their environment
    a. imbibition
    b. respiration
    c. transpiration
    d. excretion

B. The Hydrologic Cycle:

1. interrelationships of components in the basic cycle

2. the relationship of the various physical and chemical interactions to the hydroligic cycle

The material masked out on this page may be found:
WATER CYCLE DIAGRAM adapted from
Title **B.S.C.S. Molecules to Man**
Author **Houghton-Mifflin Company**
Publisher **Boston, Mass.**
Page Number **p. 652**

C. Water: The Life Blood of the Earth

1. man's gross underestimation of the importance of water to all life-forms, including himself

2. possible consequences of man's interference with processes in the basic water-cycle

3. the water-cycle in the future

D. Current Problems Concerning Air and Water Pollution

1. What efforts being made at local, state, national and international levels?

2. Man, the persistent polluter: how to stop him?

pp 72-77

The material masked out on this page may be found:

Title persistent Chemicals in the Marine Ecosystem

Author Epel and Lee

P[illegible] The American Biology Teacher

[illegible] April, 1970

REPLICATION MECHANISMS

Recommended Reading:

Biological Science: An Inquiry Into Life, (BSCS Yellow Version, Chapters 7 and 8)

Molecules to Man, (BSCS Blue Version) pp 212-218

Butler, J. A., Inside the Living Cell, Basic Books, New York, 1959

Mazia, D., "How Cells Divide", Scientific American, Sept. 1961 (offprint #93)

I. The Replication of Cells

A. Where Do Cells Come From?

1. Schwann's Hypothesis:

2. Virchow's Hypothesis:

B. Cell Division

1. Two types of Cells

a. procaryotic

b. eucaryotic

2. Problems Associated with the Division of Each Cell Type

   a. decrease in volume

      1) the procaryotic cell

      2) the eucaryotic cell

   b. decrease in the number of organelles

      1) the procaryotic cell

      2) the eucaryotic cell

3. The Results of Cell Division

   a. in unicellular organisms

   b. in multicellular organisms

      1) increase in volume when accompanied by growth

2) generation of new parts when accompanied by differentiation

3) repair and regeneration of worn-out or damaged cells.

The diagrams masked out on this page may be found:

Title Functional Organelles

Author J. Morrison

Publisher Reinhold Publishing Corporation

Page Number Fig. 1-2 p. 5, Fig. 1-3, p.8

II. The Replication of Organelles

A. The Origin and Development of Membranous Organelles

1. Chief distinction between the two cell types with regard to the functional significance of their membranes.

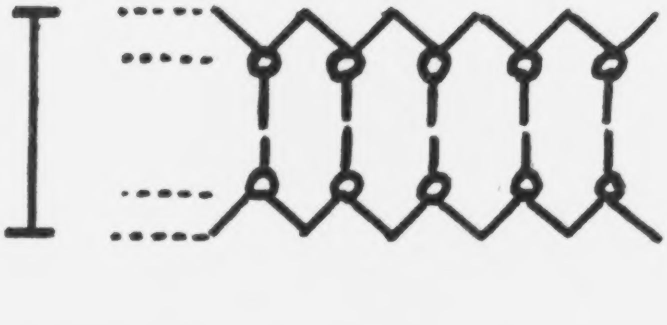
   a. procaryotic cell

   b. eucaryotic cell

2. The Unit-Membrane Theory

   a. The theory as stated:

   b. structure of the unit membrane:



c. Organelles as derivatives of the unit-membrane

1) cell membrane

2) mitochondrion

3) chloroplast

4) endoplasmic reticulum

5) golgi apparatus

6) nuclear membrane

7) vesicles and vacuoles

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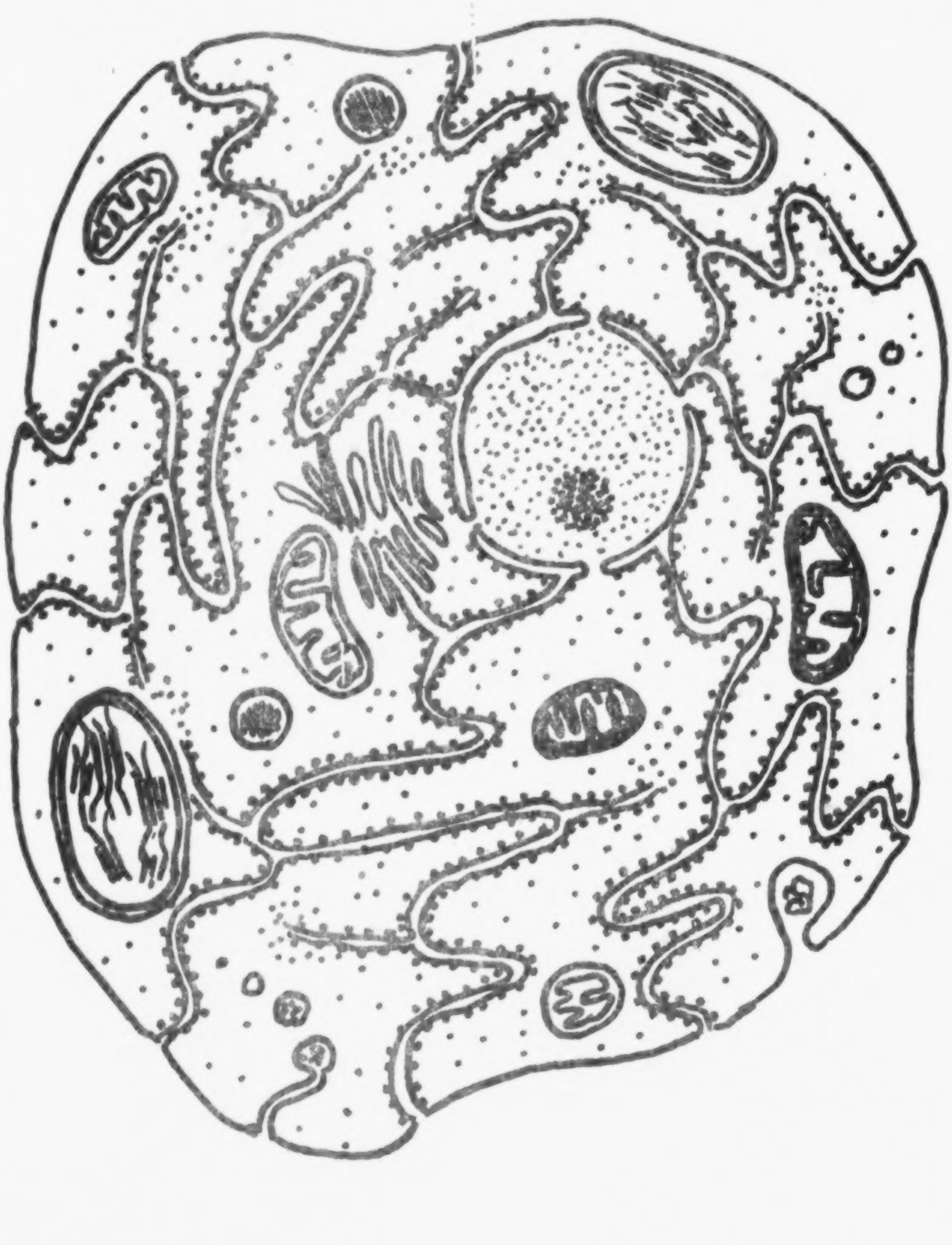
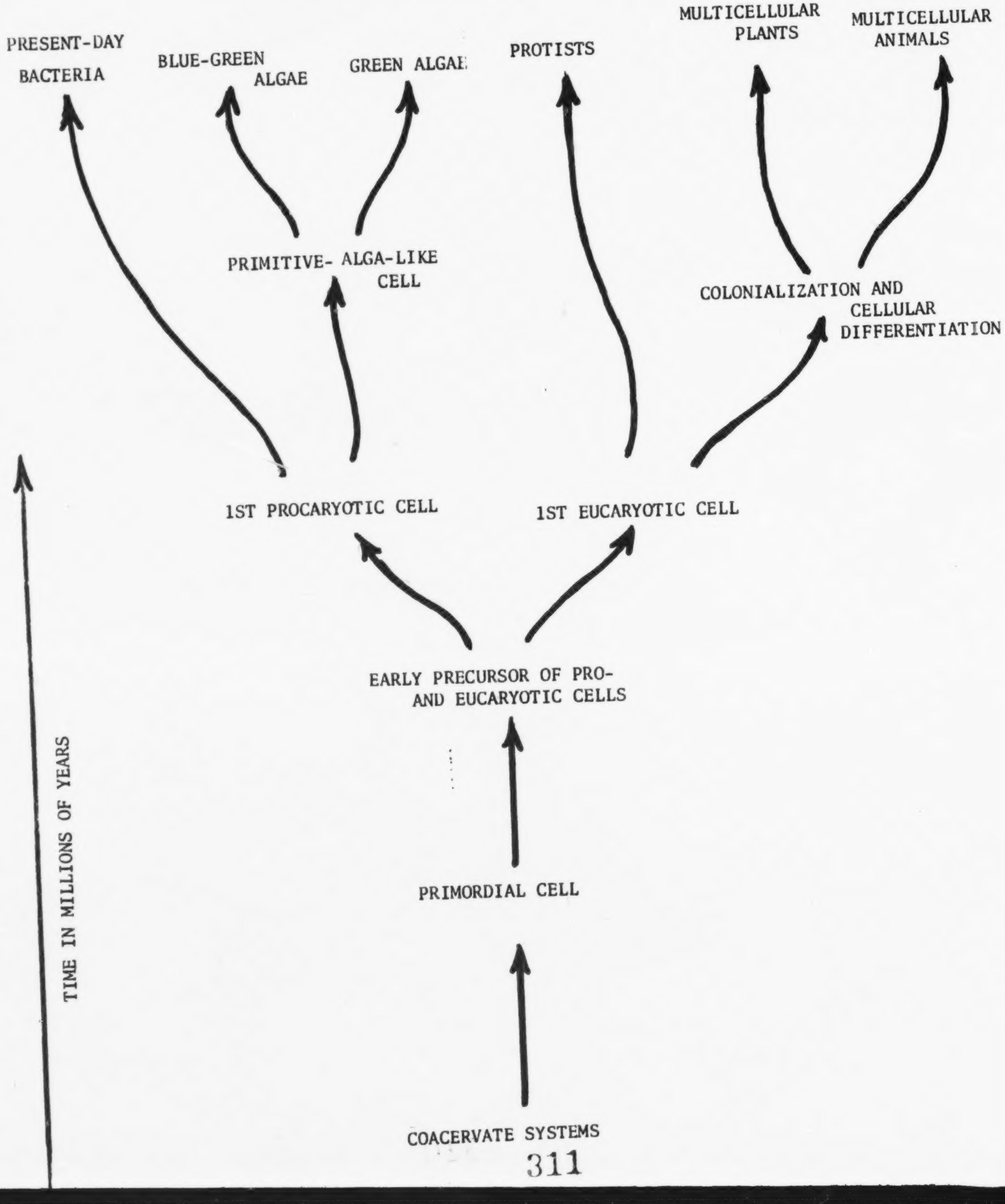
ORGANELLES-AS DERIVATIVES OF THE UNIT-MEMBRANE



THEORY AS TO HOW PROCARYOTIC CELLS, EUCARYOTIC CELLS, AND THEIR MEMBRANOUS ORGANELLES MAY HAVE EVOLVED:


PRESENT-DAY BACTERIA
BLUE-GREEN ALGAE
GREEN ALGAE
PROTISTS
MULTICELLULAR PLANTS
MULTICELLULAR ANIMALS
PRIMITIVE- ALGA-LIKE CELL
COLONIALIZATION AND CELLULAR DIFFERENTIATION
1ST PROCARYOTIC CELL
1ST EUCARYOTIC CELL
EARLY PRECURSOR OF PRO- AND EUCARYOTIC CELLS
PRIMORDIAL CELL
COACERVATE SYSTEMS
TIME IN MILLIONS OF YEARS

3. A Theory as to How the Membranous Organelles of Each Cell Type May Have Evolved

a. Assumptions upon which the theory is based:

1)

2)

3)

b. Hypothetical steps in the evolution of the various cell types - (see diagram on facing page).

4. The Formation of Membranous Organelles in Developing Cells

a. the theory of recapitulation

b. mechanisms for the formation of membranous organelles

   1) mitochondria

      a) development from the surface membrane (Figure A)

      b) development from the endoplasmic reticulum (Figure B)

      c) division of parent mitochondria

   2) plastids

      a) proplastids (Figure D)

      b) chromatophores (Figure C)

      c) chloroplasts (Figure D)

The material masked out on this page may be found:

Title **Functional Organelles**

Author **J. Morrison**

Publisher **Reinhold Publishing Corporation**

Page Number **Figs. A and B: p. 12, Figs. C and D: p.13**

3) endoplasmic reticulum and golgi apparatus

a) relationship between endoplasmic reticulum and golgi apparatus

b) development of the endoplasmic reticulum

c) development of the golgi apparatus

4) vacuoles, vesicles, and lysosomes

III. The Origin and Development of Non-Membranous Organelles

A. The Fibrous Nature of Most Ion-membranous Organelles

1. the architecture of fibers

a. polymers

b. micelles

c. collagen: an example of a fibrous unit

B. Fibrous Structures Associated with Mechanical Activity and Locomotion

1. the conversion of chemical energy to mechanical work

2. structures that accomplish this:

    a. cilia

    b. flagella

    c. nyonemes

    d. myofibuls

    e. spindle-fibers

C. Structures Associated with Nuclear Division

1. the process of mitosis outlined

a. Interphase

b. Prophase

c. Metaphase

d. Anaphase

e. Telophase

2. Structural components involved in the process:

   a. chromatin material and chromosomes

      1) architecture

      2) formation

      3) replication

         a) the process

         b) the triggering mechanism

         c) the involvement of DNA

4) origin of different chromosomal systems:

a) fracture and rearrangement

b) change in chromosome count

end-to-end fusion

dissociation

deletion

non-disjunction

b. the centriole

1) "two plus nine" architecture

2) centriole formation

3) centriole replication

4) derivatives of the centriole

a) basal granules

b) cilia and flagella formation

c) origin of rods and cones from primitive cilia

c. the spindle fiber apparatus

1) architecture

2) formation

3) function

4) analogies with other fibrous structures

D. Structures Associated with Protein Synthesis

1. ribosomes

a. architecture

b. formation

c. function

2. the nucleolus

   a. architecture

   b. formation

   c. function

IV. Some Unanswered Questions

   A. In regard to evolutionary origins, does a clear line of distinction exist between the subcellular organelle and an entrapped foreign organism?

   B. What induces the centriole or basal granule to develop into a more complex fibrous structure?

97

C. Questions Concerning Chromosomal DNA:

1. How many DNA molecules are incorporated into a particular chromosome?

2. How are these DNA molecules organized within the structure of a chromosome?

3. Does a chromosome consist of a single strand or is each type or section of DNA represented by several copies in as many separate strands? (In other words, are chromosomes simple or compound?)

4. Assuming a single continuous strand of DNA, how can it be coiled and packed into place within what is called a "lampbrush chromosome"- without resulting in an interference of the process of disciplining its code for protein synthesis?

Reproduction and Development

Name ____________________

Science IIA Hour _____

Date ____________________

REPLICATION MECHANISMS

QUESTIONS:

1. Distinguish between procaryotic and eucaryotic cell types.

   a. Procaryotic cell:

   b. eucaryotic cell

2. Diagram the structure of a unit-membrane, and give approximate dimensions of each part.

3. Describe how each of the following are thought to originate within the typical cell. Do any five.

   a. mitochondrion

   b. chloroplast

   c. endoplasmic reticulum

   d. food vacuole

e. protein-polymers

f. muscle fibers

g. flagella

h. rods and cones of the retina

4. Identify each structure or process described below:

______________________________ a. scientific term for cytoplasmic division

______________________________ b. initiates cytoplasmic division in cells of higher plants

______________________________ c. initiates cytoplasmic division in animal cells

______________________________ d. acts as organizing centers for spindle fibers in animal cells

______________________________ e. fibers radiating from the poles toward the cell membrane

______________________________ f. the diffuse chromosomal material visible in interphase

______________________________ g. phase during which chromosome duplication occurs

______________________________ h. the two immature cells resulting from cell division

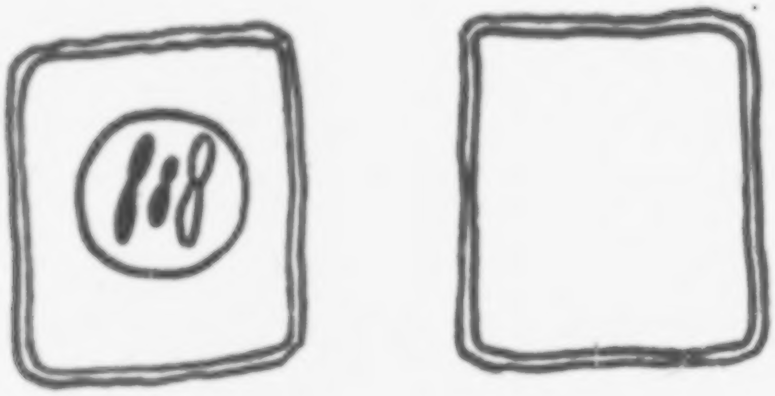
______________________________ i. a process occurring after cell division is complete

5. What are centrioles?

6. Distinguish between chromosomes and chromatin.

7. Define interphase, and indicate the activities that take place during this phase.

8. Diagram the cell below as it would appear in metaphase. Label spindle fiber, pole, chromatid, centromere, and doublet.



9. At one time many scientists thought that spindle fibers were an artifact (something that was observed in the cell as a result of preservation and staining but which was not actually a part of the dividing cell.) How did Mazia demonstrate that the spindle is not an artifact? Consult the Scientific American offprint #93, "How Cells Divide".

10. When a cell is exposed to radioactive materials scientists can observe where the materials go by observing the black grains formed by the radioactive emission acting upon photographic flim placed over the treated cells (a technique called autoradiography). If a cell were exposed to radioactive materials that would be used in the building of new DNA chains, these molecules would first become visible as parts of chromosomes during what stage of mitosis? ______________________________

11. Why do most of the cells in any one organism have the same number of chromosomes?

12. Explain the relationship among chromosome replication, mitosis, and cytoplasmic division.

13. A coenocyte (plant) or syncytium (animal) is a mass of living material containing many nuclei within one cell membrane. Explain how a coenocyte or a syncytium could develop from a single cell.

14. Some bacterial cells are divided by an inward growth of the cell wall. How is this different from the method of division typical of higher plants?

15. Describe the consequences for cellular and, hence, all reproduction if:

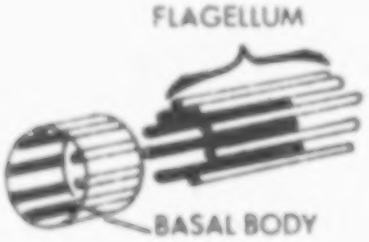
    a. no chromosome duplication preceeded division.

    b. duplicated chromosomes were divided by a pinching in of the nuclear membrane and not by mitosis.

    c. sister chromatids did not remain attached at a common point (centromere) until anaphase, but separated earlier and attached at random to different poles.

16. Colchicine is a chemical that prevents the formation of a spindle during mitosis. Thus, an onion root tip grown in colchicine solution would contain a large number of cells whose division was stopped at what stage?

17. The basal granule, a cylinder of protein associated with the long protein fibers within the flagellum, looks much like the ________________________, a cylinder of protein associated with the long protein ____________________ fibers.



Lab Investigation

REPLICATION OF ORGANELLES

Mitosis: The Mechanism of Chromosome Replication

INTRODUCTION:

If cell division is to result in the formation of two identical daughter cells each having the same kind and quantity of constituents as the original parent cell, then it is reasonable to assume that the individual parts of the original cell must, in some way, divide and separate too.

It is well known that when a cell divides, the nuclear material divides also. The chief organelles associated with the nucleus are the chromosomes, bearers of the genetic material called DNA. In a process called mitosis, these chromosomes replicate and then divide into two groups which eventually become the nuclei of two new cells that are formed by division of the cytoplasm. The process mitosis insures that the two new daughter cells will have the same full compliment of chromosomes and consequently the same genetic potential as the original parent cell possessed.

It follows that of each one of us started from a single fertilized egg cell that grew into more cells by repeated mitotic divisions, then the several trillion cells that compose our bodies all have exactly the same genetic endowment as that first tiny egg cell. How this phenomenon can occur so faithfully is one of the many mysteries of life.

Mitosis is universal among those organisms whose cells undergo it. Therefore, if we can describe the mechanism of mitosis in one kind of organism, we will have gained a basic understanding of the phenomenon as it takes place in all the other organisms.

Any actively growing tissues are good sources of cells undergoing mitosis. Certain kinds of tissues, however, because they are easily grown, easily handled, and easily stained, lend themselves more readily for our purposes than do others. It is for these reasons that the onion root tips has been chosen for use in this investigation.

PURPOSE:

To chemically prepare the dividing cells of an onion root-tip in order to observe and study the sequence of events that occur during the process of chromosome-replication (mitosis).

MATERIALS: (per team of two)

onion root-tip fixed and stored in 70% ethyl alcohol
tooth-picks
razor-blade
bulb-pipette
watch-glasses (three)
slide and cover-slip
dissecting needles (two)
paper towels
Carnoy's fixative (20 ml glacial acetic acid + 60 ml absolute ethyl alcohol)
70% ethyl alcohol
aceto-orcein stain
hydrolyzing solution - prepared in advance by mixing in the following order:
    3 parts 2% aceto-orcein stain
    1 part Carnoy's fixative
    1 part distilled water
    1 part concentrated HCl
vasoline

PROCEDURE:

The onion root-tips that you will be using as a source of mitotic cells were cut from roots grown by placing onion-bulbs in containers of water for 24 to 48 hours or until the roots had grown to a length of 5 centimeters.

The terminal centimeter of each root was then cut off with a razor-blade and placed into a fixative (Carnoy's solution) which instantly stopped the progress of mitosis and preserved the cells from decomposition.

After 24 hours in the fixative, the root-tips were transferred to 70% alcohol for storage until needed for this investigation.

1. Obtain a root-tip from your instructor and immediately place it in a watch glass containing 5 drops of 2% aceto-orcein and 1 drop of hydrolyzing solution.
2. Heat gently over a very low flame until vapors appear at the surface. DO NOT BOIL. Set aside for 5 to 7 minutes to allow the root-tips to become sufficiently softened by the action of the hydrolyzing solution on the cellulose in the cell-walls.
3. After the hydrolysis step is complete, transfer the root-tip to another watch-glass containing several drops of 2% aceto-orcein stain. Again, heat gently until vapors appear, but do not boil. Set aside for 10 minutes to allow the stain to thoroughly penetrate the cells.
4. Carefully transfer the stained root-tip to 3 drops of fresh 2% aceto-orcein stain on a clean glass-slide. Then, with very slight downward pressure, gently flatten the root-tip once, using the flat-end of a toothpick.
5. In the usual manner, place a cover-slip down on the drop of stain containing the root-tip. Then carefully invert the slide and place it cover-slip down on a clean, unwrinkled sheet of paper toweling.
6. To the back of the slide, apply a light downward thumb-pressure only, just sufficient to blot away the excess stain from under the cover-slip.

7. Now the cells must be carefully squashed in order to spread them out into a thin layer to permit easy viewing of them individually. To do this, turn the slide over again, cover-slip up. Lightly tap the cover-slip with the handle of a dissecting needle. Then press the handle to the cover-slip and circle it around several times over the area where the tissues of the root-tip can be seen.
   Finally, place a small piece of paper toweling directly on top of the cover-slip, and apply gradual moderate-to-strong thumb-pressure to increase squashing.

8. If air bubbles are drawn in under the cover-slip during step seven, they can usually be displaced by adding a drop or two of stain to one edge of the cover-slip while blotting at the opposite edge. The capillary-force exerted by the blotting paper should cause the stain and any air bubbles to flow out from under the cover-slip.

9. Gently blot away any excess stain on the slide.

10. To retard evaporation, seal the cover-slip by applying a very thin line of vasoline along all four edges. Slides prepared in this way will last for several weeks if kept refrigerated.

11. If there is time left, go on to the observations and questions which will be continued in tomorrow's laboratory session.

Laboratory Investigation

Name ______________________________

Science IIA Hour ____

Date ______________________________

MITOSIS: The Mechanism of Chromosome Replication

OBSERVATIONS AND QUESTIONS:

Using 100X, 430X, and oil immersion objectives as directed by your instructor, find, draw, and label each of the following stages of mitosis:

a. A cell in which the nucleus is not preparing to divide and its chromatin material appears to be dispersed in granular form. One or more light-staining nucleoli may be seen within the nucleus. Such a cell is sometimes called a "resting" cell because it is not undergoing mitosis, but we must remember that as long as it lives, every cell must ceaselessly continue its dynamic functions of growth and metabolism and thus really never rests.

1. Why do you suppose that chromosomes cannot be seen in resting cells?

a. ____________________

b. A stage in which the chromatin material has become aggregated into a number of long and slender, stained threads. Although separate ones cannot be identified because they are still tangled and twisted about one another, these are the chromosomes and their appearance in this elongated form is the first visible indication that a nucleus is beginning mitosis.

2. Is it still possible to see the nucleoli at this stage?

3. Is a nuclear membrane still present?

b. ____________________

c. A stage in which the chromosomes are shorter, thicker, and dark-staining and have become grouped together in the middle of the cell. Just prior to this stage, each chromosome has replicated by dividing lengthwise to form two identical halves which are called daughter chromosomes. Under the oil-immersion objective (970X), a non-staining structure called the centromere may be seen holding each pair of daughter chromosomes together at one point.

4. Is there any evidence of a nuclear membrane and/or nucleoli?

c. ____________

5. What form has been assumed by most of the chromosomes?

6. In what direction do the limbs of these chromosomes extend? Toward the center or toward the ends of the cell?

By closing down your iris-diaphragm and tilting your mirror back and forth just a bit, you may be able to find a spindle-shaped group of fibers radiating out from opposite ends of the cell to the chromosomes at the equatorial plane (an imaginary plane passed through the middle of the cell bisecting it into two symmetrical spind-fibers, consult your teacher for supplementary pictures which will show them. Spindle fibers from each pole are attached to the centromeres of the chromosomes.

7. How many chromosomes can you count at this stage?

8. Do any of them appear to be double?

9. Can you suggest a reason why?

10. Why is it not possible for you to see all of them as double in any one part of the cell?

d. A stage in which the daughter chromosomes have separated into two groups and have begun to move to opposite poles of the cell.

11. How many daughter chromosomes are there in a cell of this stage?

12. In what direction are the chromosome limbs pointing? Try to find the spindle-fibers again or consult the pictures that your teacher has.

13. In view of your answer to question 12, what relationship do you think the spindle-fibers might have to the separation and movement of the daughter chromosomes to their respective poles?

d. ____________

e. A stage in which the daughter chromosomes have arrived at their respective poles and have become crowded together to form two new daughter nuclei in the single cell. The daughter chromosomes are still visible but only as tightly twisted, elongated strands. The beginnings of a new cell wall may be visible between these daughter nuclei. If you cannot find a cell of this stage that shows it, consult the supplementary pictures again.

14. Where in the mother cell does the wall appear?

15. Does it extend beyond the width of the spindle?

e. ________________

16. What does your answer to question 15 seem to suggest about the relationship of the cell wall to the spindle?

GENERAL CONSIDERATIONS:

a. Observe the large spread of cells which appears in your low-power (100X) field. Notice that some of the nuclei appear to be stained darker than others.

17. Is there any relationship between the intensity of staining and the condition of the nuclear material?

18. Describe the nature of this relationship.

19. Can you propose a few possible explanations for this?

b. By now you have noticed that only a relatively small number of cells on your slide are in some stage of mitosis. Give some idea as to the relative abundance of mitotically active cells and the cells which were not undergoing some stage of mitosis at the time when your root tip was fixed. To provide a quantitative answer to this question, determine the frequency (X100 = %) of cells undergo mitosis by using the following formula:

$$\frac{\text{number of mitotic cells}}{\text{number of mitotic cells + number of non-mitotic cells}} = \text{frequency of cells in mitosis at time of fixation}$$

Simply count up the number of mitotic cells and divide by the total number of cells that you see in your entire 430X field (or within the largest square of a Whipple micrometer grid used at 430X).

20. Determine the frequencies of five different non-overlapping areas on your slide.

21. Determine the average of these five figures.

22. Report your figures when class data are pooled on the board. When all class data are available, determine class averages. Enter all figures in the appropriate places on the data sheet.

23. Would you expect the frequency to be larger or smaller for a sample of cells taken from the parts above the roots?

24. Why?

25. Do the frequencies observed in the root tips suggest to you any ideas as to how often the cells of an active growth region divide?

26. Do you think that the frequency remains constant throughout the life of the root - or does it vary with the root's age?

27. How do you suppose the frequency of mitosis relates to the length of the root tip?

28. Design an experiment to verify your answers to questions 26 and 27.

REPLICATION MECHANISMS

Replication of Molecules

A Reading

Experimental evidence has shown that a particular large molecule, called DNA, which makes up the genetic material of the nucleus is able to control the activities of cells. This evidence raises a number of important questions. For example, how are DNA molecules able to exert this powerful control? And how are cells able to transmit their remarkable characteristics to their descendents? Are these properties common to all forms of life? We will see how the language of life is written in a molecular code. The messages of the code, when translated by the cell, tell it how to synthesize particular protein molecules. Many of these proteins are enzymes that catalyze chemical reactions in the cell, and in this way control most cell activities.

In general, all living organisms duplicate or reproduce themselves. An important question to consider here is how do they transmit their particular characteristics, or traits, to their descendents? One hypothesis suggested as an answer to this question is that perhaps each kind of molecule in the cell can make an exact copy of itself at the time of cell division. Then every kind of substance and structure important to life would be present in the new cells. This would have to mean that the remarkable property of self-duplication would be characteristic of every kind of molecule in the cell. At present, however, there is no evidence that the organic molecules, sugars, fats, proteins and others can duplicate themselves.

We can, therefore, consider a second hypothesis: One group of molecules contains the information about how to make all the other kinds of molecules of a cell. The molecules of this group would then be a master library of instructions on how to synthesize the many other kinds of molecules needed. This idea is actually very close to what biologists believe today. Many kinds of experiments have indicated that the NUCLEIC ACIDS may be this group of molecules. Biologists know that nucleic acids can control cell activities. They also know that nucleic acids can make exact copies of themselves and are found in the reproductive cells (sperms and eggs) of all higher forms of life. Thus, nucleic acids not only exert remarkable control over cell processes, but also provide a chemical link from one generation to the next. Since function depends on structure, an important question to ask now is - is there anything about the structure of nucleic acid molecules that suggests their ability to carry volumes of information? Can they function as a storehouse of information for the cells, and can these directions be transmitted in a code form of some kind? We assume that they can.

MECHANISMS OF LIFE PROCESSES

Reproduction and Development

REPLICATION MECHANISMS

Replication of Molecules

Required Reading: BSCS Blue Version, pp 142-150, Ch. 7

I. DNA is the Only Molecule Capable of Self Replication

  A. The Unit of Structure of DNA

  B. The Secret of Replication - the Base Pairs

II. The Process of Self Replication

  A. The DNA Molecule Prior to Division

  B. The DNA Helix Begins to "Unzip"

  C. New Code Units Join Dividing Units According to Directions

D. Two Helixes Start to Grow from the Original Splitting Helix

E. Completion of Division - Two Identical Molecules

III. The Replication of DNA is the Basis for all Growth and Reproduction

A. DNA Duplication in Mitosis

B. DNA Duplication in Meiosis

IV. Changes in the Code - Mutation

A. Definition of Mutation

B. Causes of Mutation

1. Accidental Rearrangement

2. Nucleotide Shortage

3. X-Rays and Other Radiations

4. Chemicals

C. Effect of Mutation on the Cell

D. Error Control Mechanisms - Can DNA Repair Itself

V. In Addition to Replicating DNA Also Controls All Cell Activities by the Biosynthesis of Protein

A. Review of Protein Synthesis

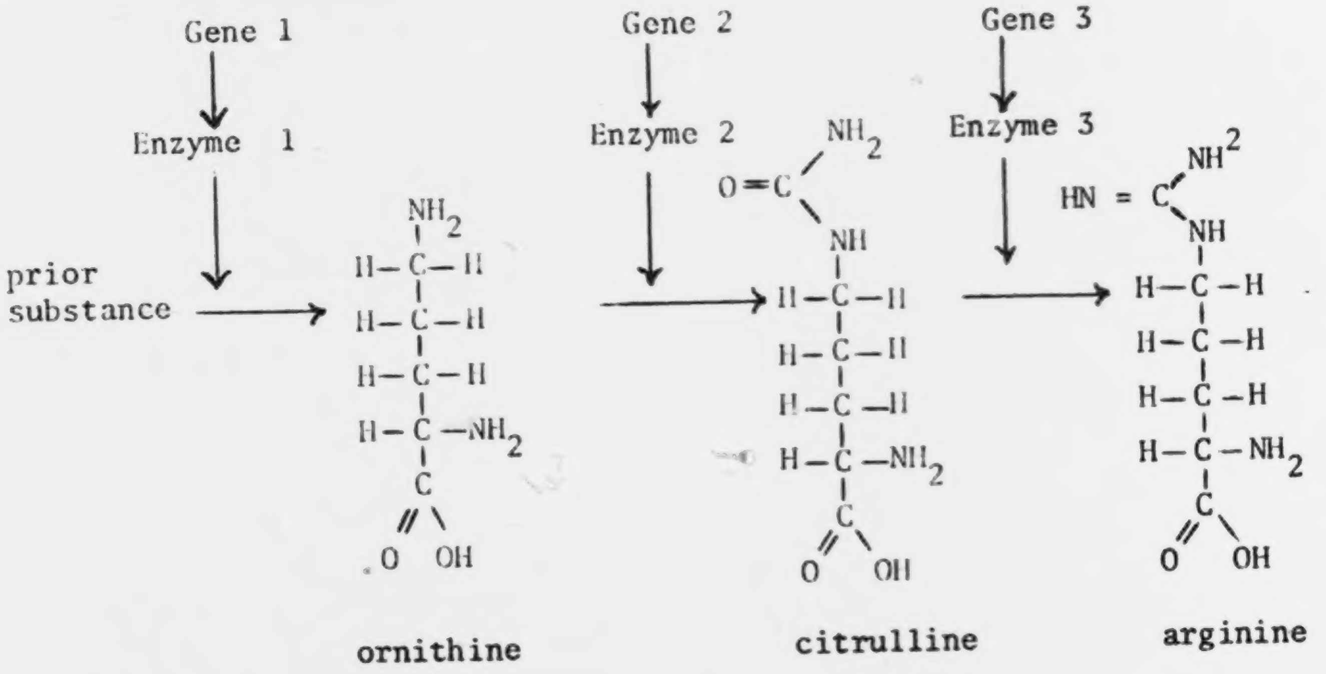
B. The Work of Beadle and Tatum - The One Gene-One Enzyme Hypothesis

The Work of Beadle and Tatum

"One Gene - One Enzyme" Hypothesis

Major Concept: Investigations on the bread mold Neurospora led to the hypothesis that genes control the synthesis of specific enzymes which are proteins. The enzymes in turn catalyze particular steps in building molecules in the cell.

Introduction: A relationship between genes and enzymes was assumed long before there was any knowledge of biological code messages, messenger RNA, transfer RNA, and the role of ribosomes in protein synthesis. This relationship was termed the "one gene - one enzyme" hypothesis and can be diagrammed in the following way:



From this example we can see that each enzyme changes the molecule slightly by catalyzing the addition or removal of a few atoms. Biologists believe that usually a specific gene is responsible for the activity of each enzyme.

REPLICATION MECHANISMS

Replication of Molecules

An Outside Reading

NOTE: In July, 1970 the scientific community made a profound discovery, and that was that protein synthesis does not always work exactly as scientists had thought. The following article is reprinted from TIME Magazine, July 20, 1970, the Science Section.

Upsetting Dogma

For more than a decade, most scientists have accepted the central dogma of molecular biology without question. Stated simply, that dogma holds that the heredity information in living cells is always passed along in the same direction: from the "double helix" DNA molecule to the single-stranded messenger RNA molecule, which in turn directs the synthesis of protein -- which is essential to all life. Since the end of May, however, investigators at three separate laboratories have stunned the scientific community by revealing that the central dogma is contradicted by the activities of cancer-producing viruses.

The dogma was challenged experimentally in 1964, when Howard Temin of the University of Wisconsin suggested that certain viruses consisting of only RNA and a protein sheath may cause cancer by making their own DNA once they invade a host cell. This new DNA would then become permanently incorporated in the host cell, giving orders for the production of cancerous cells and more cancer-producing viruses.

Invading Viruses. Teminism, as the theory came to be called, received little support from other scientists; it suggested that RNA could pass genetic information along to DNA, a clear reversal of accepted dogma. But Temin refused to abandon his idea. He knew that tumor-causing RNA viruses somehow inject their deadly message permanently into the host cell; otherwise, the cancer would not be passed on during cell division to future generations of cells. Yet the invading viruses carry with them no DNA of their own. Therefore, Temin reasoned, they must somehow make DNA after invading the host cell. The only way to do this would be by passing information from RNA to DNA.

Last month, Temin with his colleague, Satoshi Mizutani, and David Baltimore of M.I.T. published back-to-back papers in the journal Nature offering experimental evidence that RNA viruses causing cancer in animals are capable of assembling their own DNA. Their work was quickly confirmed by Sol Spiegelman, head of Columbia University's Institute for Cancer Research and one of molecular biology's most brilliant experimenters.

All three researchers confirmed the fact that viral RNA material was indeed producing its own DNA. They labelled four chemical building blocks of DNA with a radioactive isotope of hydrogen called tritium. After mixing the building blocks with viral RNA, the "tracer" element appeared in what was chemically identified as DNA. Thus it was apparent that the RNA had assembled the blocks to form DNA in its own image.

Backwards Reaction. One of Spiegelman's checks was even more convincing. He reasoned that if the RNA had served as a template for DNA, the RNA would be complementary to one strand of the DNA and should be able to join it, forming a double-stranded hybrid. He mixed minute amounts of both molecules and whirled them in a centrifuge for three days. Because the density of RNA is different from that of DNA, the strands gradually separated in the test tube, forming two distinct layers. To his delight there also appeared a third layer, which proved that a product of intermediate density -- the combined RNA-DNA molecule -- had indeed formed.

This result persuaded Spiegelman to throw his support behind Teminism. "We tend to believe that nature is uniform," he says, "so I was just as skeptical about the Temin hypothesis as everyone else. But there were so many peculiarities that could not be explained by what we already knew that it became clear he really had something."

So far, Spiegelman has tested twelve RNA viruses for this "backwards" reaction. Eight of them, which cause tumors in animals, can do it; four, which do not cause tumors, cannot. Circumstantially at least, the results hint that a virus capable of causing cancer might depend upon this reaction. Researchers are already trying to relate these results to virus activity in humans and identify the enzyme that governs the reaction. It is already known that the transfer of genetic information from DNA to RNA can be blocked; an antibiotic can knock the crucial enzyme out of action. Once the key enzyme that enables RNA to produce DNA is identified, the reverse reaction -- and perhaps cancer itself -- could conceivably be stopped in the same way.

Reproduction and Development

Name ______________________________

Science IIA Hour _____

Date ______________________________

QUESTIONS FOR CONSIDERATION BASED ON REQUIRED READINGS:

1. Why was epigenesis a difficult hypothesis to reconcile with what was known of mitosis and the division of a fertilized egg?

2. Has preformation been disproved? If so why do animals produce offspring only of their own species? Why, for example, does a cat never give birth to anything but kittens?

3. How may the experiments of Roux and Driesch best be interpreted?

4. What was Spemann's hypothesis about the differentiation of the embryonic cells that give rise to the nervous system? How did his experimental work with embryos support his hypothesis?

5. What evidence suggests that chemical influences are a basic factor in cell differentiation?

6. In what way is the regeneration of a lost part by an adult organism similar to the developmental problem in embryos?

7. Generally speaking, the capacity for regeneration decreases as complexity and specialization in animals increases. Can you suggest a reason why?

8. In what way is the problem of cancer related to an understanding of developmental processes? Can you suggest how increased knowledge of the mechanisms of embryonic development may help lead to more successful treatment of many types of cancer?

9. Which of the basic processes of development (cell division, growth, and differentiation) are exhibited by the following: (a) the development of a starfish egg into a ball of cells? (b) the development of a bean seed into a flowering plant? (c) the development of a frog blastula into a gastrula? (d) the adult life of the Chimney Tree? (e) the regeneration of a limb by a salamander?

10. What conclusion could you draw from Roux's experiment without knowledge of Driesch's experiments?

11. What conclusion could you draw from Driesch's experiments without knowledge of Roux's experiments?

12. What lesson regarding experimental results and conclusions based on them can you draw from the experiments done by Roux and Driesch?

13. Why have scientists been able to use abnormal development of organisms as a way of understanding normal development?

14. Why are the ideas of "preformation" and "epigenesis" inadequate explanations of development?

15. What theory can you apply as an explanation of the organization of the egg as it begins development?

REPLICATION OF ORGANISMS

Suggested Reading: Biological Science: An Inquiry Into Life (BSCS Yellow Version) pp. 246-251; 257-261; 267-275. Chapter 17: pp 309-316. Chapter 26: pp 472-492

Biological Science: Molecules to Man (BSCS Blue Version Chapter 13: pp 261-291

I. Asexual Reproduction

A. Asexual reproductive processes in general

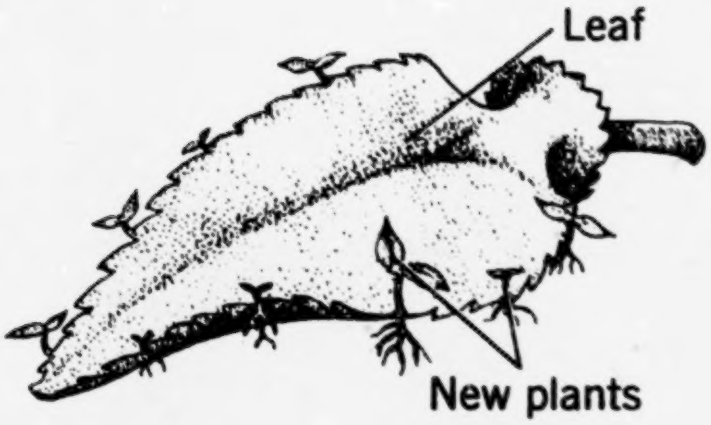
B. Common types of Asexual reproduction

1. fission

2. spore formation

3. fragmentation

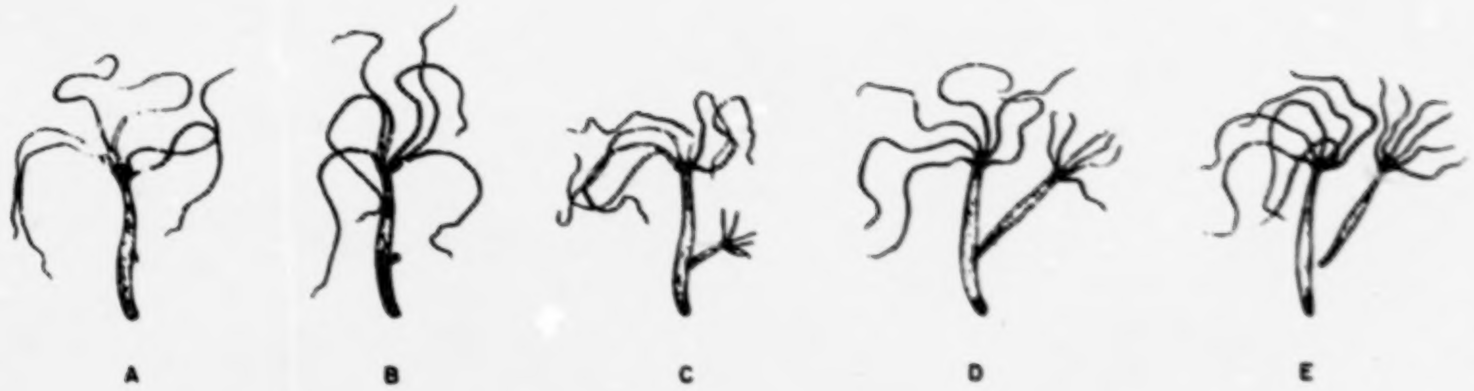
4. budding



BRYOPHYLLUM: note the tiny new plants developing at the leaf margins.

5. strobilization

6. vegetative reproduction



HYDRA SHOW ASEXUAL (BY BUDDING) REPRODUCTION

II. Sexual Reproduction

A. The Basic Process of Sexual Reproduction

1. sex defined

2. gamete formation: the process of meiosis

3. the process of fertilization

B. Simple Forms of Sexual Reproduction

1. transduction

2. conjugation followed by fission

C. Forms of Sexual Reproduction that Involves the Production of Gametes

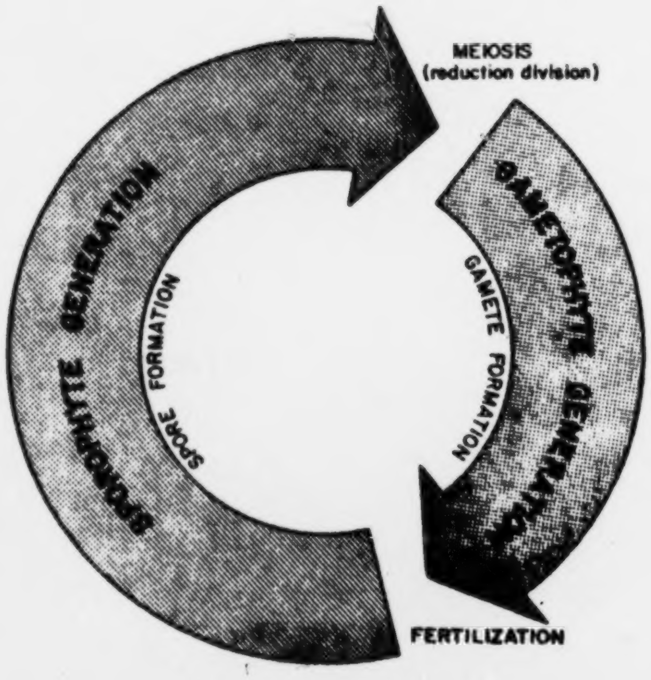
1. Plants

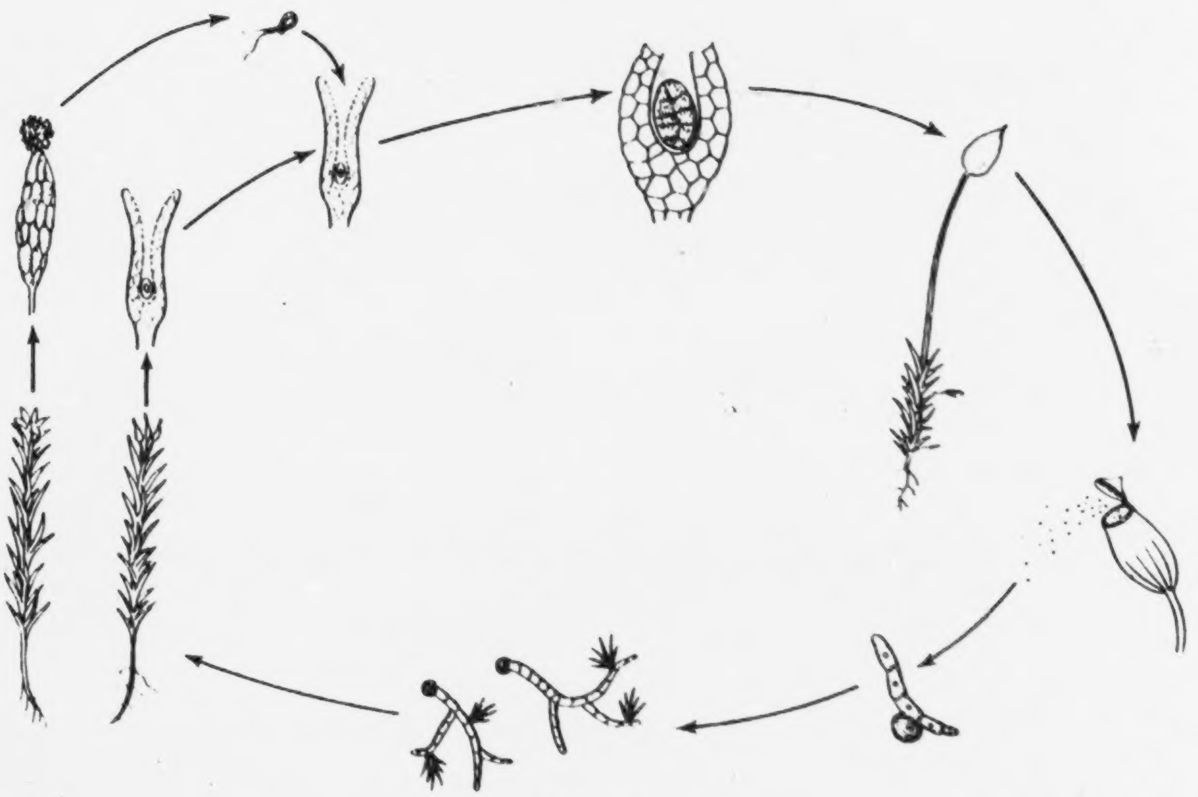
a. isogamous reproduction

b. heterogamous reproduction

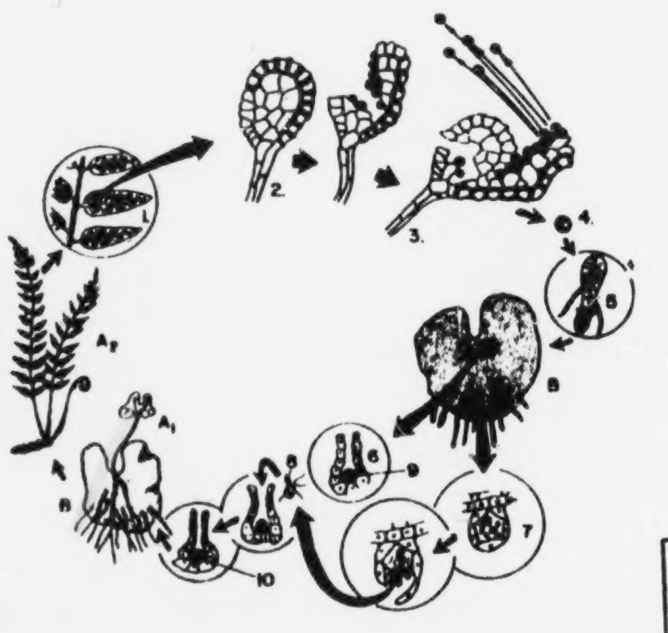
c. alternation of generations

1) the basic cycle


MEIOSIS
(reduction division)
GAMETOPHYTE GENERATION
GAMETE FORMATION
FERTILIZATION
SPOROPHYTE GENERATION
SPORE FORMATION

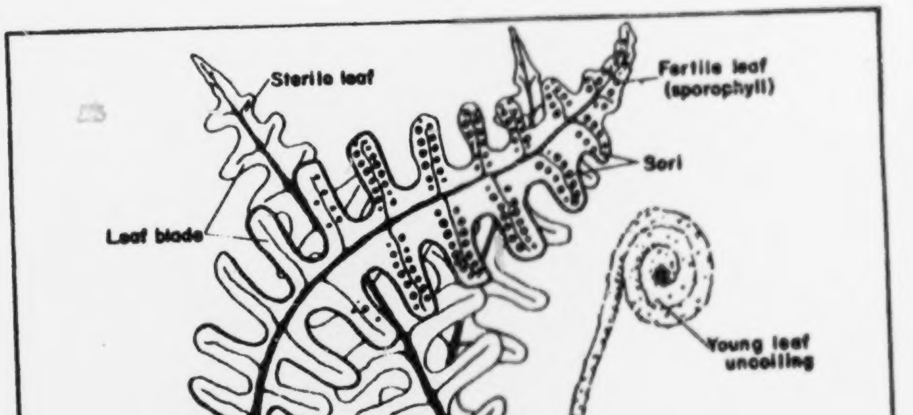


Life cycle of a moss


1
2
3
4
5
6
7
9
10
A₁
A₂
B

Life Cycle of Fern

Leaf Showing Spore Producing Structures (Sori)


Sterile leaf
Fertile leaf (sporophyll)
Sori
Leaf blade
Young leaf uncoiling
Petiole
Stem
Adventitious roots

2) the evolution and variation of the alternation-of generations life-cycle

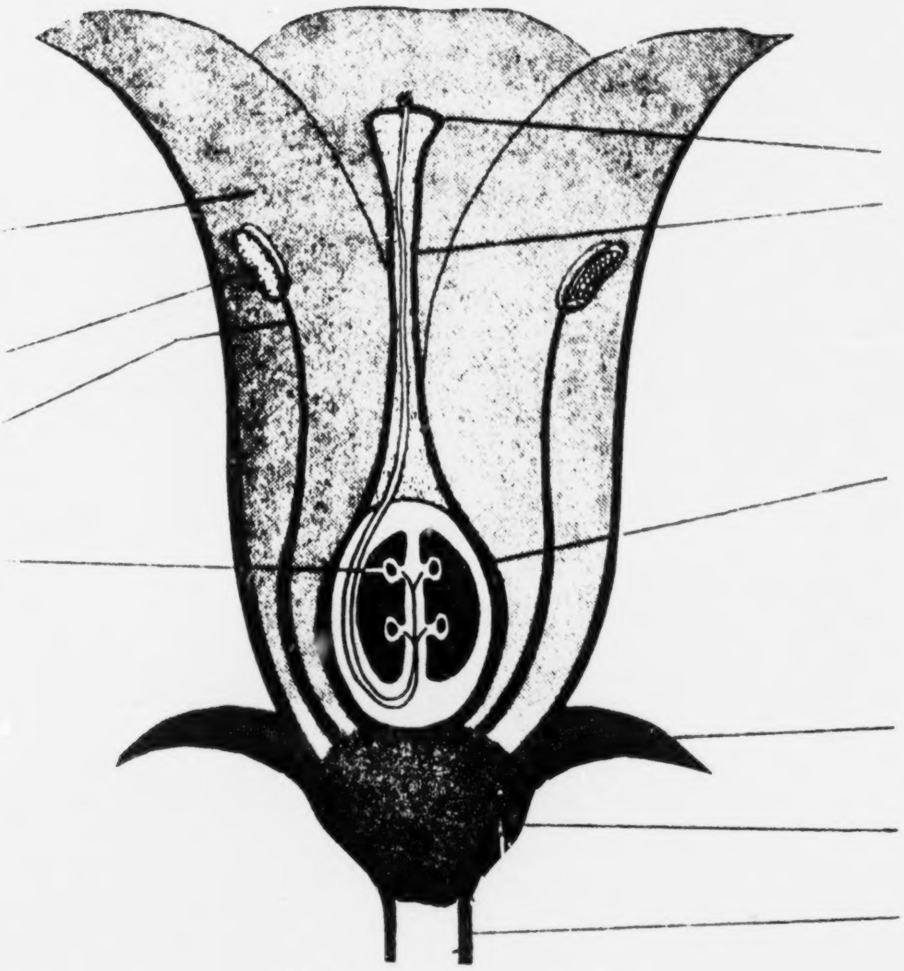
a) gametophyte dominant

b) sporophyte and gametophyte equally dominant

c) sporophyte dominant

-protection of seeds in a cone

- protection of seeds in an ovary



FLOWER: Showing Reproductive Parts and Pollen Tube Formation

Laboratory Investigation

ALTERATION OF GENERATIONS

PURPOSE:

The purpose of this exercise is to demonstrate the alteration of generations in a green plant and to correlate this phenomenon with reproduction.

PROCEDURE:

We are used to seeing moss plants growing in clumps and forming mats of plants on logs and on the forest floor. These plants, like the liver worts, grow best in damp, shaded environments. A clump of moss plants is composed of many, many gametophytes all growing close together. Sporophytes grow out of the tops of the gametophytes, and they are produced in large enough numbers to look like hairs growing out of the clump of moss plants.

Sporophyte: Take a moss plant with a sporophyte attached. Pull the filamentous stalk of the sporophyte out of the leafy shoot of the gametophyte. These two generations are now separated.

The sporophyte part of the moss has a smooth, leafless stem terminated by a little capsule. With a dissecting needle, break open the capsule of the sporophyte into a drop of water on a slide, and apply a cover glass.

1. What do you think the powdery material in the capsule should be if this is a sporophyte?

   With the high power of the microscope, look at the spores.

These tiny cell will produce the new gametophytes.

2. How are they distributed in nature?

3. Do they have thick or thin walls?

4. How are they adapted for life on land?

Gametophyte: The spores of most bryophytes germinate readily on damp soil. There they produce a filamentous stage that looks more like a branching green alga that a part of a moss plant.

The filamentous stage gives rise to the leafy shoot of the gametophyte. This is a photosynthetic, independent structure.

5. How does this leafy shoot obtain water for growth?

It is this part of the plant which produces reproductive organs and gametes - thus it is called the gametophyte. Let us take an ant's-eye view of the sex organs, which are produced at the upper end of the leafy shoot.

The best way to study these reproductive organs is to dissect or squeeze them from the tips of the leafy shoot. Take a male or female plant so that the tip is between your thumb and forefinger. Squeeze the tip and at the same time roll it between your thumb and forefinger. Now submerge the tip of the leafy shoot in a drop of water on a microscope slide and tease out the fragments from the tip of the shoot with a needle. Some of the fragments will be the moss sex organs. Follow the same procedure for both male and female moss plants. Put a cover glass over the fragments from each plant and observe the preparations under the low power of your microscope.

The male sex organs are simple, sac-like structures. In nature they produce large numbers of sperm cells. The female sex organs are flask shaped and have long, twisted necks. An egg is formed within the swollen base of the female organ.

6. How does a sperm reach the egg for fertilization?

7. Would you expect to find moss plants growing where there was little or no water present? Explain.

8. Into what does the zygote grow?

9. Which generation is initiated by the zygote?

10. In alteration of generations in a moss, which is the predominant, independent generation?

11. Which is the less conspicious one?

Laboratory Investigation

FERNS - A PRIMITIVE VASCULAR PLANT

PURPOSE:

The purpose of this exercise is to become familiar with a primitive vascular plant and its method of reproduction.

PROCEDURE:

The Sporophyte: Examine an entire fern plant which has been removed carefully from the soil. Notice the horizontal underground stem, the roots, and the leaves. (1) What are the youngest leaves? (2) What shape are they before they are fully developed? In the alteration of generations the fern plant is the mature sporophyte. (3) How does it compare with the sporophyte of a moss plant in complexity, longevity, and method of nutrition?

Now observe the upper and lower surfaces of the leaves. Notice that some of the leaves have small brown dotlike or elongated structures on them which are sometimes mistaken for parasitic insects or fungi. Scrape some of the brown material onto a slide and prepare it for examination under the microscope. The small, stalked structures seen are spore cases. Notice the row of thick-walled cells across the top and back of the spore case. Some of the spore cases probably will have been broken by handling and the spores scattered on the slide. Other spores can be observed still in the vases. (4) What part of the moss sporophyte is similiar in function to the spore cases of ferns?

Examine a slide of the cross section of fern stems. Draw a sketch of what you see, and label the various parts.

The Gametophyte: Spores which settle from the air in moist, shaded places germinate to form green, generally heart-shaped plants about as large as a fingernail. Each of these structures is a mature gametophyte. (5) Would it be easy to find where a fern gametophyte grows in the woods? Explain. (6) How does the gametophyte of a fern compare with that of a moss in food-getting, longevity, and function?

Put a living gametophyte on a glass slide and examine it first with the dissecting microscope. Look at the lower surface. (7) What structures are present for water absorption? (8) In what other plants have you seen these structures? In addition to the absorbing structures, sex organs are also located on the lower surface. To see these, use the low power of your compound microscope.

The male sex organs are dome-shaped structures which generally develop in advance of the female sex organs. Look for the male sex organs near the margins of the gametophyte. Crush a male sex organ in a drop of water on a clean glass slide. Look for sperm cells in the water. They are quite small. (9) Is there any movement of the sperm cells? (10) What is your conclusion about how sperm cells reach the egg cells in a fern plant? (11) How does this compare with the situation in an alga, and in a moss?

The female sex organs are flask-shaped structures with the enlarged basal portion buried in the tissues of the gametophyte and with the neck projecting above the surface. The enlarged basal portion contains an egg. If you cannot find the female sex organ on the living plant, look at the demonstration slide. The egg is fertilized inside the female sex organ. (12) What name is given to a fertilized egg? (13) What generation, in the alternation of generations, is initiated by the fertilized egg? (14) Which generation is the predominant one in a fern life cycle? (15) Which generation is photosynthetic? (16) Why do ferns normally not inhabit dry environments?

Laboratory Investigation

THE IMPORTANCE OF SEEDS

PURPOSE:

The purpose of this exercise is to observe the structure of an advanced vascular plant and to study its reproductive cycle for comparative purposes.

PROCEDURE:

The pine branch: Generally the end branches are elongated, but the side branches remain short and spurlike. Notice the brownish, inconspicuous leaves at the base of needlebearing branches.

Needle leaves in different species may vary from a single leaf on each short basal stalk to as many as eight. Two, three, and five needles are the most common. (1) How many leaves are borne on each stalk in the species of pine that you are observing?

Most broad-leaved trees of temperate regions shed their leaves each year, but needle leaves may remain on the pine for periods ranging from two to fourteen years. They are shed gradually, although some species may show a more marked seasonal shedding of branches and leaves than others. Notice old scars on the stem where leaf-bearing branches were once attached. (2) How would you describe the arrangement of these scars: opposite, alternate, or spiral? Identify the part of the stem which was produced during the last year of growth. In a similiar manner attempt to identify the part of the branch which is two years old. (3) Can you estimate the age of the oldest needles on the branch in your possession?

The pine tree with its roots, trunk, and branches is the mature sporophyte. (4) How does this compare with the sporophyte of a fern as to size, and method of nutrition?

Pine cones: Seed cones are produced singly or in groups of two to five. Pollen cones, on the other hand, usually occur in closely packed clusters of ten or more near the tip of a branch. (5) Can you suggest why it might be advantageous to the pine to produce more of one kind of cone than the other?

The small, spirally arranged cone scales making up most of the pollen cone are modified leaves so specialized that they hardly resemble leaves. Place one of these leaves under the dissecting microscope. Notice the two elongated spore cases on the lower side of each cone scale. Crush a spore case on a clean glass slide, use a cover glass, and examine the specimen under the high power of the microscope. (6) What are the small structures with little bladders? (7) What part do they play in the life cycle?

Now look at the young seed cone. The spirally arranged cone scales are fleshy and may prove to be a little difficult to pry apart. At the base of each cone scale on the upper side you should find a pair of white or cream-colored bumps. These are the ovules that will grow into seeds. (8) How are the ovules of a pine protected? (9) How do you suppose the sperm cell reached the egg in the ovule? (10) How are the seeds, resulting from growth of ovules, shed from the cones? To answer this look at an old seed cone which has shed most of its seeds.

The seed: Break the seed coat and remove it. Inside you will find a white, fleshy tissue. This is like a lunch basket in the seed. It is stored food or endosperm. (11) How is the endosperm used? The answer to this question lies in the very center of the food itself. With a sharp razor blade make a lengthwise cut through the center of the endosperm and look at the cut face. If you have made the cut properly you will see the embryo, which is surrounded by the stored food. Now you can answer question 11. (12) Which would you think has the better chance of survival, the spore of a fern or moss, or the seed of a pine. Give your reasons.

2. Animals
    a. types of sexual reproduction
        1) external fertilization, external development within an egg

        2) internal fertilization
            a) external development within an egg

            b) internal development within an egg or within a uterus

    b. reproduction in placental mammals
        1) the male reproductive system

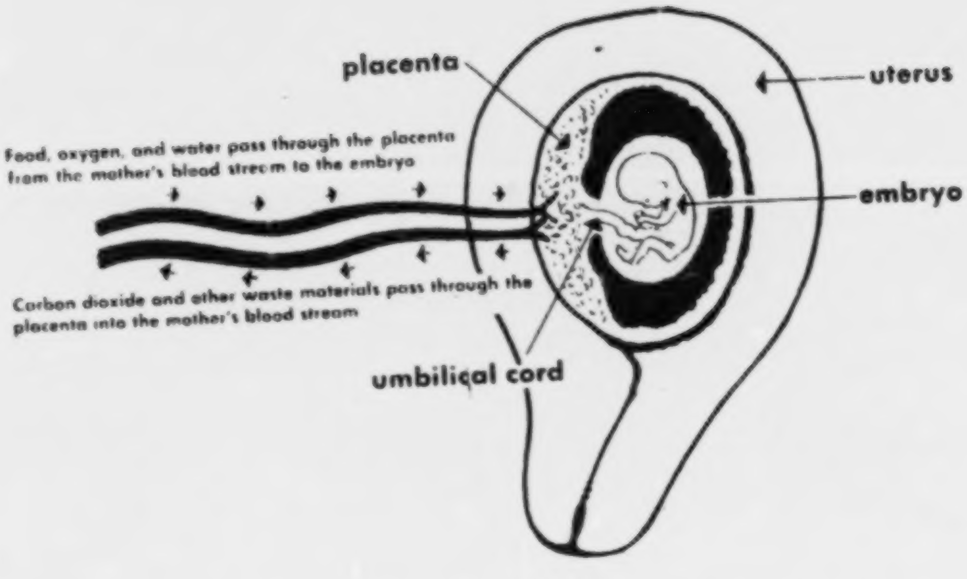
        2) the female reproductive system with cycles
            a) the menstrual cycle

b) pregnancy

-structure and function of the placenta

-the birth process

-lactation


placenta
uterus
Food, oxygen, and water pass through the placenta from the mother's blood stream to the embryo
embryo
Carbon dioxide and other waste materials pass through the placenta into the mother's blood stream
umbilical cord

3) hormonal control of mammalian reproduction

  a) the hormones

  b) hormone interaction in reproduction

c. Behavioral Aspects of Sexual Reproduction

1) general pattern

  a) selection of breeding habitat

  b) nest-building

  c) courtship

  d) mating

  e) protection and care of young

2) some examples

Exercise

Name ____________________

Science IIA Hour _____

Date ____________________

SEXUAL REPRODUCTION

1. Describe the process of meiosis.

2. Why would it be necessary to assume that a process such as meiosis occurs during sexual reproduction even if there were no direct evidence that it did occur?

3. Why is fertilization a necessary part of sexual reproduction? What role do chromosomes play in sexual reproduction?

4. How are some of the disadvantages of external fertilization partially overcome?

5. What is the advantage of sexual reproduction to a species?

6. What are some of the factors that contribute to the great success of the flowering plants?

7. What is one of the major indications of the extent of evolution of sexual reproduction in plants?

8. What is the advantage to plants of the production of many more pollen grains than eggs?

9. How do such membranes as the allantois, yolk sac, amnion, and chorion make it possible for eggs to develop outside a watery external environment?

10. In the human, how does the quantity of sperm cells produced compare with the quantity of egg cells?

11. Name the stages of the human menstrual cycle.

12. Trace the development and passage of an ovum in the female reproductive system.

13. Account for the delay of menstruation if fertilization occurs.

14. How do pituitary hormones function in the reproductive cycle of mammals?

15. What is the role of the ovaries in the hormonal control of the reproductive cycle?

16. What becomes of an ovarian follicle after the egg cell is released?

17. What is the role of the placenta in internal development?

18. As the embryo develops what changes occur in the developing placenta?

19. In what ways do the reproductive processes of plant and animal species depend on environmental conditions?

20. For what reasons is migration essential to the reproduction of certain species of birds and mammals? How has man interfered with this migratory behavior and what could be the consequences?

GROWTH AND DEVELOPMENT

The Events of Development

Required Reading: BSCS Yellow Version, Chapters 27 and 28
BSCS Blue Version, pp 293-324

INTRODUCTION:

Development of a complete organism is a complex series of events consisting of cell division, growth, and most difficult of all to understand, differentiation. Biologists have worked for a long time just to find out what actually happens as an organism develops. But these are simply the events of development, they tell us nothing about how they occur. How can a frog egg develop into a tadpole, and then into a frog? How can a bean seed develop into a bean plant?

Nature sometimes "interferes" with normal development, and unusual organisms develop from apparently normal eggs and normal seeds. Biologists began to realize that the way they could learn more about normal development is to study what happens when normal development is interfered with. Thus, the experimental study of defelopment began at the end of the 19th century, when biologists developed methods of interfering with normal development. Such studies yielded information on how one tissue affected the development of another tissue in the developing embryo.

With great advances in the field of genetics in the 20th century, and the subsequent unlocking of the genetic code within the last decade, studies of differentiation have been extended to the molecular and chemical levels. We shall look at some of the problems inherent in the study of development and differentiation and the methods employed in the past and at present to answer some of these questions. Before we can examine the problems of differentiation in development, a quick review of what actually occurs in development is necessary.

A. The Events of Development In Vertebrate Embryos

1. Cleavage

a. Human

b. Amphibian - Frog

c. Birds - Chick

2. Cavities

3. The Primary Cell Layers

B. Events of Development in Plants

1. Beginnings - Early Development

2. The Primary Growth Tissues in Plants

C. Unusual Kinds of Development

1. Regeneration in Plants

2. Regeneration in Animals

3. Uncontrolled Growth

Laboratory Exercise

GROWTH AND DEVELOPMENT

Watching Cells Grow

(Source - American Biology Teacher,
February, 1953

INTRODUCTION:

Each of us started our life as a single cell so tiny it is just barely visible to the unaided eye. This first cell began to divide shortly after fertilization and from one cell an embryo formed. The embryo began to take in raw materials from its environment and became even larger because of further cell division. This increase in mass we call growth, and whether it occurs in plants or animals it is due to cell division, or mitosis, which depends on the replicating ability of DNA in the chromosomes.

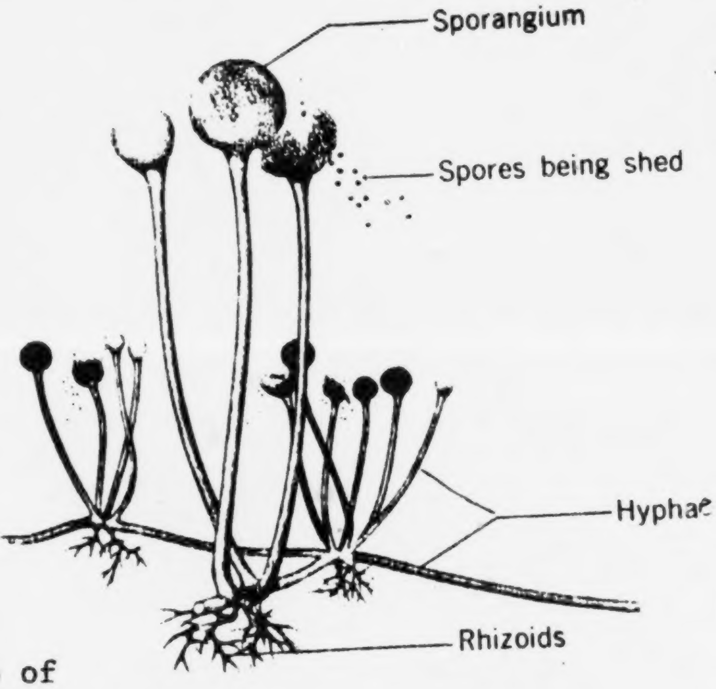
One thing to note here is that growth merely means an increase in mass, it has nothing to do with the development of structure or form.

PURPOSE:

To observe growth in a living fungus, Neurospora.

DIRECTIONS:

Neurospora is a member of the group of living things called a fungus. This means that its vegetative structure - the fluffy mass of thread like structures - is made up of HYPHAE. All hyphae have cell walls on their outer edges and may be divided by SEPTAE. Fungi are commonly found in the soil with other fungi and bacteria. They usually have specialized hyphae which bear spores. The spores develop in a spore case called a SPORANGIUM and when this case ruptures thousands of spores are released into the air. Below is a diagram of one type of fungus.



In this lab period you will actually observe cells grow. This is possible because of the very rapid growth which occurs in cells at the tips of hyphae in the fungus Neurospora. You will be given a petri dish containing a thin layer of agar medium. (If you are curious, this medium is made of 3.0 g glucose, 0.5 g KH_2 PO_4, 0.7 g yeast extract, 2.0 g agar added to 100 ml. water.) The day previous to your lab the agar plate has been inoculated (ie. sprinkled with) in the center with spores of Neurospora. When you receive the plate the hyphae will be advancing across the surface of the agar. Take a very clean cover slip and removing the top of the petri dish place the cover slip on top of the growing hyphal front. Be sure that half of the cover glass is over bare agar so you can see the hyphae growing. Press the cover glass lightly to remove air and to allow the moisture from the agar to fill in under the cover slip. Place the petri dish directly on the microscope stage and observe first with low and then high power.

Locate the zone of hyphal tips and watch a single tip carefully. Then move the place around and observe various hyphal tips. Make two sketches for LOW POWER and HIGH POWER on the lab report sheet which follows, labeling any structures you observe.

QUESTIONS: Answer on Lab Report Sheet

1. Were you able to observe any movement of the protoplasm in the hyphal tips?

   What might cause such movement?

2. Were you able to observe septa separating hyphal cells? Are these the same as the cell wall?

3. Are all the cells in the growing hyphae the same length?

   Hypothesize an explanation for your answer.

4. This fungus is growing at a tremendous rate and there is a very rapid increase in mass. Since matter can't be created, where is this new mass coming from?

LAB REPORT SHEET

Name ______________________________

Science IIA Hour _____

Date ______________________________

Watching Cells Grow

low power

high power

QUESTIONS:

1.

2.

3.

4.

Small Group Investigation

GROWTH CURVES

INTRODUCTION:

The sets of data given below are records of growth in three different organisms. From these data you should be able to determine some general characteristics of growth that are common to all organisms.

Record A: The height of a stem of bamboo, one of the most rapidly growing of all plants, was measured from the time the sprout came up.

Age in Weeks	Height in Meters
1	0.7
2	1.5
3	2.5
4	4.0
5	6.2
6	8.3
7	10.2
8	12.0
9	13.2
10	13.8
11	14.1
12	14.2

Record B: A turkey was weighed every month from the time of hatching until it had reached almost full size.

Age in Months	Weight in Kilograms
0 (just hatched)	0.05
1	0.60
2	2.06
3	3.95
4	6.22
5	8.37
6	10.64
7	12.65
8	14.58
9	14.82

Record C: A large number of corn seedlings were grown under favorable conditions. Every two weeks a few plants were weighed, and the average of their weights was recorded.

Age in Weeks	Average Wt. in Grams
2	21
4	28
6	58
8	76
10	170
12	422
14	706
16	853
18	924
20	966

PROCEDURE:

Prepare a graph of each set of data with age on the horizontal axis and the size on the vertical axis.

Select one of the three sets of data, and from it prepare another type of graph. Again plot age or time on the horizontal axis, but this time on the vertical axis plot the amount of growth since the previous measurement. The bamboo, for example grew 0.7 m in the first week, 1.5-0.7 = 0.8 in the second week, 2.5-1.5 = 1.0 m in the third week, and so on.

QUESTIONS:

1. Describe the general shape of the three growth curves you prepared first. In what ways are the curves similar to each other? In what ways are they different?

2. When does the most rapid growth occur?

3. How do you think these curves would compare with curves describing your own growth in height and weights, respectively?

4. What is the relationship between the second type of curve you drew and the first set of curves?

5. By now you have had some experience in working with the metric system. Do you think that in one meal your family could eat the nine-month-old turkey in Record B?

Laboratory Investigation

REGENERATION AND RECONSTITUTION IN HYDRAS

INTRODUCTION:

The ability of many invertebrates to reconstruct a whole animal from a part of their body was first discovered in 1740 in experiments performed on hydras. These pioneer experiments were performed by Abraham Trembley, a tutor at the French court, who fished some hydras out of the pools at Versailles and studied their capacity to regenerate after being cut in pieces.

PROCEDURE:

You will need:

some hydras that have been recently fed
a small, sharp scalpel or razor blade (or planaria knife)
a shallow dish in which to cut (the bottom of an inverted finger bowl is good)
a small culture dish with culture solution

Raising Hydras in the Laboratory: In some areas there are minerals in water which are harmful to hydras. Special solutions have been developed which are more satisfactory than untreated water for culturing hydras in the laboratory.

Hydras in nature feed on tiny plants and animals. In the laboratory Artemia (brine shrimp) serve as an excellent food. Decaying food is harmful to hydras. Therefore, it is necessary that you drain off the culture solution 20-30 minutes after each feeding, replacing it with fresh solution. In studying normal growth rate you should feed the hydras each day throughout the entire observation period.

Prior to feeding the hydras each day, you should count and record in your notes the number of hydranths in each culture dish. Hydranths are feeding mouths - therefore, in counting them you will add the total number of hydras to the total number of buds showing hydranths in each dish. If time permits, count the hydras after changing the solution to be sure you have not lost small hydranths with the solution.

Heads and Bodies: Obtain 5 or 10 hydras from the stock dish. With a medicine dropper transfer them, 2 or 3 at a time, to a shallow layer of fluid in a dish or depression slide. When they have relaxed, cut them as shown in Figure 2. Place the hydranth pieces in one culture dish and the body pieces in another and keep them at room temperature. They do not need to be fed or changed. Inspect each dish daily for 10-14 days. Do the hydranth pieces re-form a body? Do the pieces re-form a hydranth? Record your observations in the form of notes and sketches in your notebook.

Body Segments: Take several hydras, as in the last procedure and cut out the body, as shown by the solid lines in Figure 2. Place the isolated bodies in a culture dish and inspect daily. In a second series, cut out the bodies; then cut them in half (dotted line in Figure 2) and place the anterior and posterior halves in separate dishes. Will any of these pieces regenerate whole hydras? Inspect them daily and record your observations as above.

Tentacles: Take some whole hydras or freshly amputated hydranths and cut out single tentacles. Place the isolated tentacles in a culture dish and inspect them daily to see if they can reform into whole hydras. Record your observations as before.

Foot-pieces: Take some whole hydras or freshly discarded basal ends. Cut off the foot-pieces, by which the animals attach themselves, with a part of the stalk. Isolate these pieces in a culture dish and determine whether they can regenerate hydranths and bodies. Inspect them daily and record your observations as before.

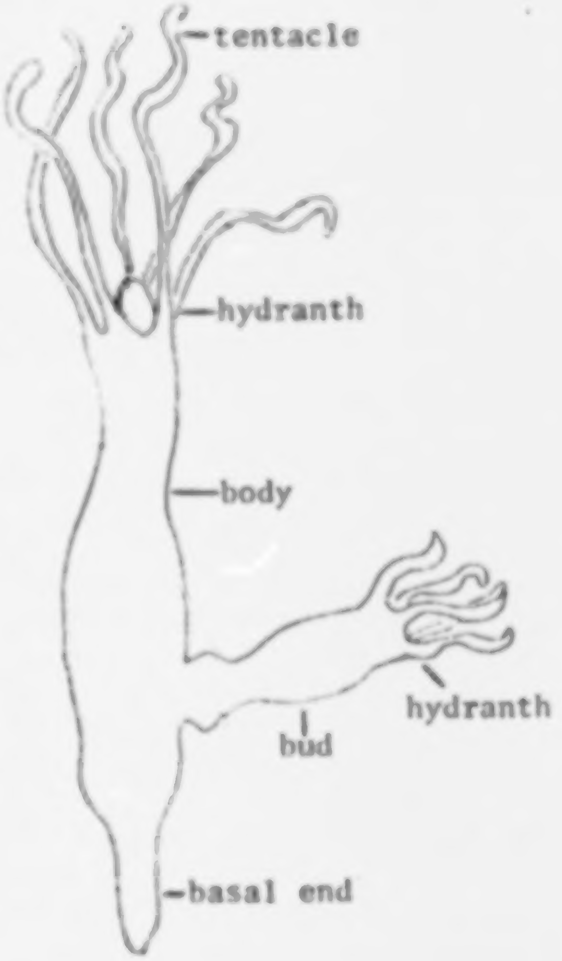

tentacle
hydranth
body
hydranth
bud
basal end

Figure 1: Hydra showing bud and external body structures.

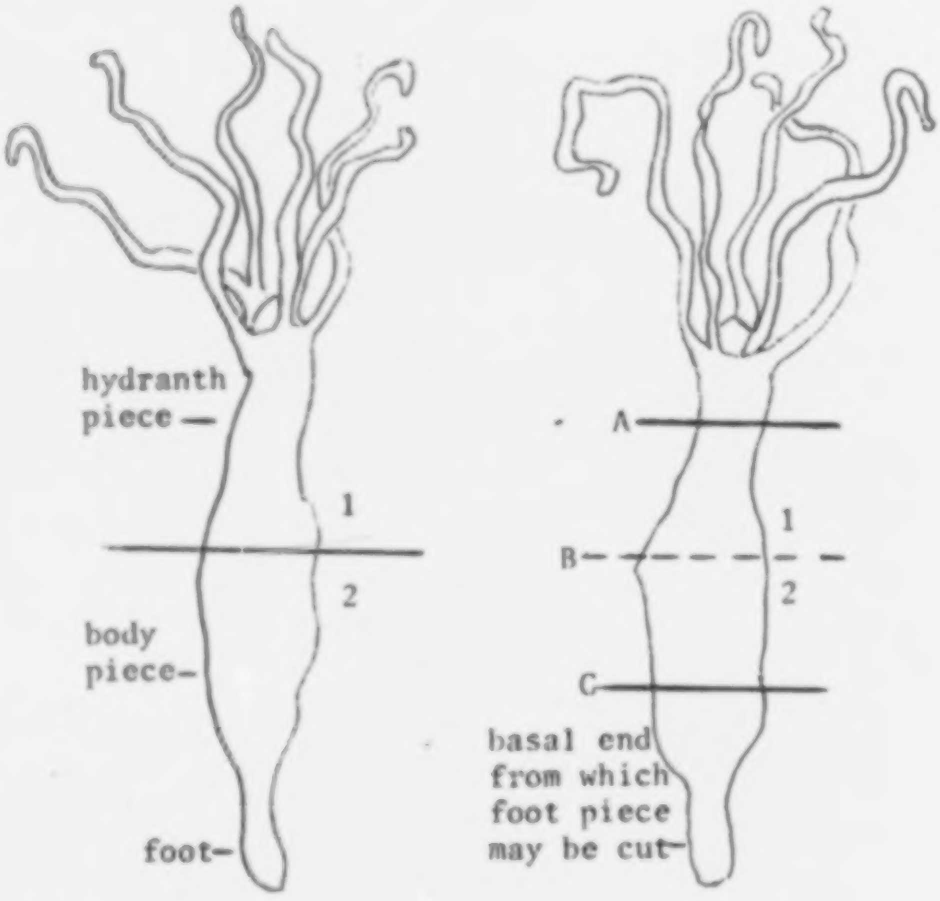

hydranth piece
1
2
body piece
foot
A
1
B
2
C
basal end from which foot piece may be cut

Figure 2: Sectioning a hydra for regeneration.

Laboratory Investigation

THE REGENERATION OF THE TADPOLE'S TAIL

The adult frog, like most higher vertebrates, has no capacity for replacing parts of its body that have been lost. Interestingly enough, however, the frog in its tadpole stage does show the capacity for regeneration that its salamander cousins retain into adult life. When its tail is cut off, the tadpole will frequently grow a new one. Because the development of the new tail really represents the return to embryonic conditions, embryologists have often studied tail regeneration in an effort to learn more about the forces that cause a mass of undifferentiated cells to develop into a perfect organ neatly fitted to its place in the whole animal.

In the following experiment we shall clip the tails of some anaesthetized tadpoles, and then wait to see whether the tails grow back again. If they do, we shall be able to determine how long the regeneration process takes and whether the new tail has the right size and shape to match the tadpole's body.

PROCEDURE:

You will need:

several tadpoles in any stage between Stage 25 and the onset of metamorphosis
narcotic solution (0.04% chloretone, or other narcotic)
culture dishes
large-mouth medicine dropper
very fine sharp scissors
pond water

As you proceed with this work, assign one member of your squad to make sketches of the tadpoles before and after the tail is cut off. Clearly show the general outline of the body and tail.

Place several tadpoles in a shallow dish of the narcotic solution and wait for them to become motionless. If they do not move when you jiggle the dish, they are anaesthetized, and you can proceed. Use scissors to snip off half (or a little more than half) of the tails of some of the tadpoles at right angles to the long axis of the body. With the remaining tadpoles, cut off the tail obliquely (i.e., at a sloping angle). Discard the tails. Transfer the tadpoles to fresh pond water. If space permits, it would be desirable to put each tadpole in a separate small dish; otherwise, those with tails cut at right angles should be kept separately from those with tails cut at oblique angles. Be sure your sketches show the slope of the cut surface.

It will be necessary to maintain these tadpoles for about one week. Feed and clean them daily.

CONTINUING THIS EXPERIMENT:

At 2-day intervals examine the cut surfaces of the tadpoles' tails. Each time you look at them answer the following questions:

1. Has the wound healed?
2. Has a mass of new tissue (the regeneration blastema) appeared?
3. Is there pigment (color) in the new tissue?
4. If a new tail is forming, is it correctly aligned, or is it set at some angle to the long axis of the body?
5. Has a new tail fin developed?
6. If a new tail fin has developed, does it exactly replace the old one, or is it smaller or wrinkled or abnormal in some other way?
7. Does the new tail move?
8. Are there blood vessels in the new tail?

Sketch a few tadpoles that seem to be representative each time you examine them. Be careful to show the size and orientation of the regenerated portion in relation to the old tail stump and the rest of the body.

Continue your observations until regeneration is complete in at least half of the tadpoles you operated on.

GROWTH AND DEVELOPMENT

Differentiation: An Analysis of Development

Required Reading:	BSCS Blue Version, pp 311-323
Recommended Reading:	Scientific American Offprint #103, "The Organizer" Scientific American Offprint #45, "How Do Cells Differentiate?" Scientific American Offprint #94, "How Cells Specialize"

I. Problems of Differentiation

It is interesting to note that from a single fertilized egg cell the adult human develops having about fifty trillion cells. What is really surprizing about this is the fact that these 50 trillion highly specialized cells in the developed organisms could have arisen by no more than forty-seven cell divisions. If you doubt this, and have the patience, you can work out the calculations yourself - from one cell comes two, from two comes four, from four comes eight, etc. The problem of differentiation lies in the fact that cells of each specialized organ and tissue in the developed organism must develop its particular properties during these mere forty-seven divisions.

A. Theories of Differentiation

1. Preformation and Epigenesis

2. Mosaic Theory

3. Regulative Development

4. "Organizer" Concept

III. Recent Work on the Problem of Differentiation

Question: How can all the cell differences in an adult plant or animal arise from cells of the early embryo that are so much alike?

A. The Work of Hans Spemann

1. Differentiation of Nervous Tissue

2. Role of the Mesoderm as an Inducer

B. Embryonic Induction in the Development of the Eye

C. The Work of Huang and Bonner - Molecular Studies

1. Protein Inhibition of Certain Genes

2. Projections for the Future

5. Theories from Recent Genetic's Research

    a. Cells differentiate by losing sets of genes

    b. Cells differentiate by inhibiting certain genes

II. Early Work of the Problem of Differentiation

A. The Work of Roux and Driesch

1. Wilhelm Roux - half an embryo from half a fertilized egg

2. Hans Driesch - an entire embryo from half a fertilized egg

B. Reconciliation with Older Ideas of Differentiation and Development

Laboratory Investigation

EMBRYONIC DEVELOPMENT OF GUPPIES

PURPOSE:

To learn the techniques involved in obtaining, handling, and staging guppy eggs and embryos and to observe the general stages in their development.

MATERIALS: (per team of two)

- female guppy
- culture dish
- Syracuse dishes (set of six)
- scissors
- forceps (two)
- steel probe
- glass ball probe
- transfer-pipette (wide-mouthed)

(per lab)

- MS-222
- Holtfreter's solution
- Stockard's solution
- extra Syracuse dishes
- 1 dozen vials for collection of eggs and embryos in various stages

PROCEDURE:

Select a female guppy that is full in the abdomen and shows a darkened patch in the anal region. This patch is commonly referred to as the "gravid spot" and its presence is an indication that embryos in advanced stages are present. The dark color is actually due to the pigmented skin of the embryos showing through the rather thin and transparent tissues of the anal region. Sometimes embryonic eyes can be seen showing through. Obtain an I.D. # for your fish and then carefully measure the female from tip of snout to tip of tail and record this cm on the data sheet.

Place the female in MS-222 solution in a culture dish until all movement ceases. Then pith it by grasping it behind the gills with a forceps and inserting a steel probe into the brain.

Hold the fish gently in one hand, with its ventral surface up. With a sharp scissors, cut the head from the body, immediately behind the gills. Then snip the body-cavity open, starting from the point where the head was removed and continuing toward the tail until the anus is reached. Be careful not to damage any of the internal parts by cutting too deeply with the scissors or by squeezing the fish.

After the body-cavity is opened, transfer the fish immediately to 10% Holtfreter's solution and using your glass-ball probe and forceps, carefully locate the single ovary which encloses the developing eggs and embryos. The eggs and embryos will look like white and yellowish spheres grouped together in a grape-like cluster that is held together by ovarian tissue. Carefully remove the eggs and embryos from the thin ovarian tissues. This is best accomplished by grasping patches of ovarian tissue with a forceps and then pushing and prodding the embryos out with a glass-ball probe. Care must be taken not to damage the embryos or rupture their yolk sacs.

When all eggs and embryos have been freed, sort them out into separate dishes of Holtfreter's solution and according to amount of development. Number the dishes and arrange them in chronological order from least developed to most developed. It is not likely that all of the embryos from one female will be of the same age so you will need a corresponding number of dishes. The transfer pipette can be used to pick up the embryos without harming them, however any handling should be minimized and sorting should be done quickly but carefully.

After the living embryos have been carefully scrutinized for structural differences (drawings and descriptions can be included in your report), they may be fixed in Stockard's solution (poison) for three days and then placed in labeled vials of 70% alcohol for storage and further study.

As soon as you have completed the above, go on to the work described on the data sheet.

LAB DATA SHEET

Name ______________________________

Science IIA Hour ____

Date ______________________________

Embryonic Development of Guppies

DATA AND QUESTIONS:

1. Working together with your instructor and the other students in your class, arrange all eggs and embryos from earlier to later stages, putting dishes of the same stage together in a vertical row on the table and keeping dishes of eggs and embryos taken from the same female in separate, horizontal rows. Re-number the stages according to this class-arrangement exemplified below:

Fish No.	Length in cm	Stage No.												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
1														
2														
3														
4														

Each dish will then be given an identification number. For example, 1-5 contains fifth-stage embryos from fish #1. The same fish also produced stages 1, 3, 4, and 6.

2. On the chart on the following page (Table I) record the number of eggs and embryos found in each stage of development for each female, entering totals in the right-hand vertical column.

TABLE I.

Stage Numbers

Fish No.	Length in cm	1	2	3	4	5	6	7	8	9	10	11	12	total eggs and embryos in each f
Total eggs or embryos in each stage														

DATA AND QUESTIONS, Continued Name ____________________

3. Are all the embryos from a single female at the same stage of development?

4. Could all the eggs in a single female have been fertilized at the same time? Why or why not?

5. Why do these fish not need to produce a very large number of eggs in order to increase their population size?

6. What prediction can you make concerning the size and color of the gravid spot and the developmental stages of the embryos when selecting a female for observation?

7. How does the stage of development that an embryo is in at the time of its removal from its mother affect its chances for survival? What would have to be done to obtain data for plotting a graph of time alive versus stage of development at removal from the mother?

8. With both a hand-lens or dissecting scope and a compound microscope (low-power objective), observe the details of a variety of stages covering the full range of guppy development.

   In Table II on next page, check off the stages in which each structure or feature makes its earliest appearance.

TABLE II.

Structure or feature (note earliest appearance) Stage #	1	2	3	4	5	6	7	8	9	10	11	12
embyonic shield												
anterior-posterior elongation with little differentiation												
cephalic region developing												
3 regions of brain distinguishable												
body pigments restricted to head												
eye parts discernable (lens, pupil, retina)												
retinal pigmentation (shiny, metallic)												
pigmentation spread to trunk & tail												
tail-fin rays developed												
pectoral fin rays developed												
V-shaped musculature appearing along sides												
movement of trunk and tail												
swimming movements												
eye movements (nystagmus)												
heart formed but no beat												
heart beat but irregular												
regular heart beat												
blood circulating over yolk												
mouth parts developed but not moving												
mouth parts moving												
operculum developed but no movement												
regular movements of operculum indicate that gills are functioning												
dorso-ventral balance												
vertebrae and ribs formed												

9. What observation can you make concerning the size relationship of the yolk to the embryo as development progresses?

10. Observe the circulation of blood through the yolk in one of the later embryos. Why do you suppose the blood circulates through the yolk?

11. Can you determine the path and direction if circulation between the embryo and yolk? Draw a diagram to illustrate your findings. Indicate flow directions with arrows.

12. Using a later stage embryo, draw a dorsal view of the head showing the sense organs and regions of the brain.

13. From the same embryo, draw a detailed dorso-lateral and ventro-lateral view of the eye. Label the following structures:

    a. capillaries
    b. lens
    c. pupil
    d. retina and retinal pigments
    e. fissures and raphes (lines where growing tissues meet)

14. Is there any evidence that any of the fish you have observed are able to focus upon objects? Hint: What is nystagmus? Can you observe this phenomenon in any of the embryos?

Laboratory Investigation

DEVELOPMENT OF THE CHICK EMBRYO

NOTE: It will be possible to do only one of the following labs. Should you be interested in attempting any of the labs not done in class, please see your teacher.

INTRODUCTION:

Most multicellular plants and animals develop from a single cell - a fertilized egg cell. What is the course of this complex process of development? What structures act as organs of respiration, nutrition, and excretion for the developing embryo? In what order do these structures appear in the embryo? From your study of embryonic membranes, you already know some partial answers to these questions. In this laboratory investigation you can further explore these problems by examining fertilized chicken eggs at different stages of development.

MATERIALS:

- fertilized, unincubated eggs
- egg incubated for about 3 days
- egg incubated for about 5 days
- three culture dishes
- dissecting microscope or hand lens
- fine-pointed scissors
- forceps
- dropper
- paper towel

PROCEDURE:

Place crumpled paper toweling in the bottom of each culture dish to keep the eggs from tipping. In removing the eggs from the incubator do not rotate them any more than necessary. Keeping each egg in the same relative position, place it in the culture dish. Let the eggs stand several minutes so that the embryos will float to the tops of the yolks.

Without removing the egg from the dish, cut away the shell from each egg, as illustrated in Figure 1. (In the 5-day embryo, the yolk will be quite watery. Be careful not to insert the scissors too far under the shell. Cut only with the scissor tips.)

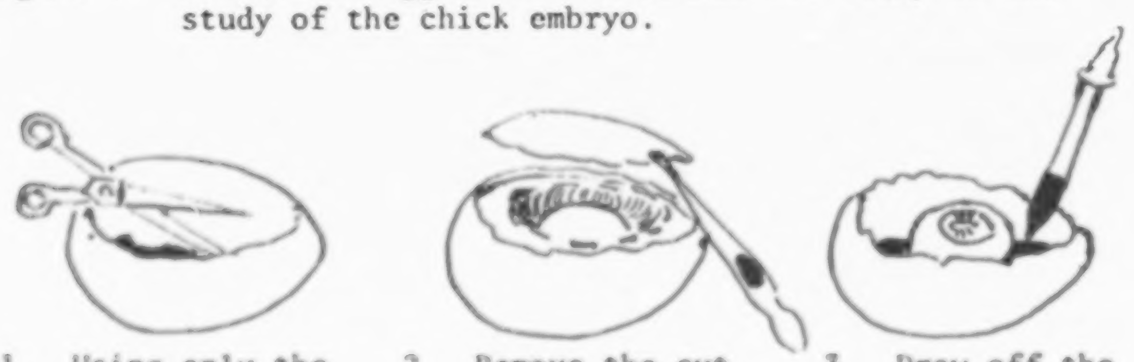
Observe the structures in the unincubated egg. (Place the egg and culture dish under the dissecting microscope, or use a hand lens for your observations.) By the time the fertilized egg has been laid, some development has taken place. Compare the appearance of the unincubated egg with that of the 3-day egg. In addition to the embryo itself, what other structures are evident in the 3-day egg? What is the function of the blood vessels radiating from the embryo?

Now look at the membranes surrounding the 5-day embryo. Note the yolk sac which covers part of the yolk. What is the function of the yolk sac? Next find the allantois. At this stage, it is a small, balloonlike sac; during later development, the allantois will expand until it makes contact with most of the lining of the cell. Through the allantois the embryo obtains oxygen and disposes of some gaseous wastes. Where do you think liquid waste is stored? Next, look for the amnion, the membrane immediately surrounding the embryo. Gently probe the surface of the amnion. What do you think the cavity is filled with? What would be a possible source of this fluid?

Using forceps and scissors, carefully open the amnion of the 5-day embryo. Now examine the embryos of the 3- and 5-day chicks. In which embryo can you see the heart beating? Why not in both embryos? Does either embryo have a tail? A neck? Does either embryo have noticeable wing or leg development? Describe. Compare the relative sizes of the eyes and the brain in the two embryos studied.

If possible, examine eggs at later stages. Try to trace the development of the various parts of the chick.

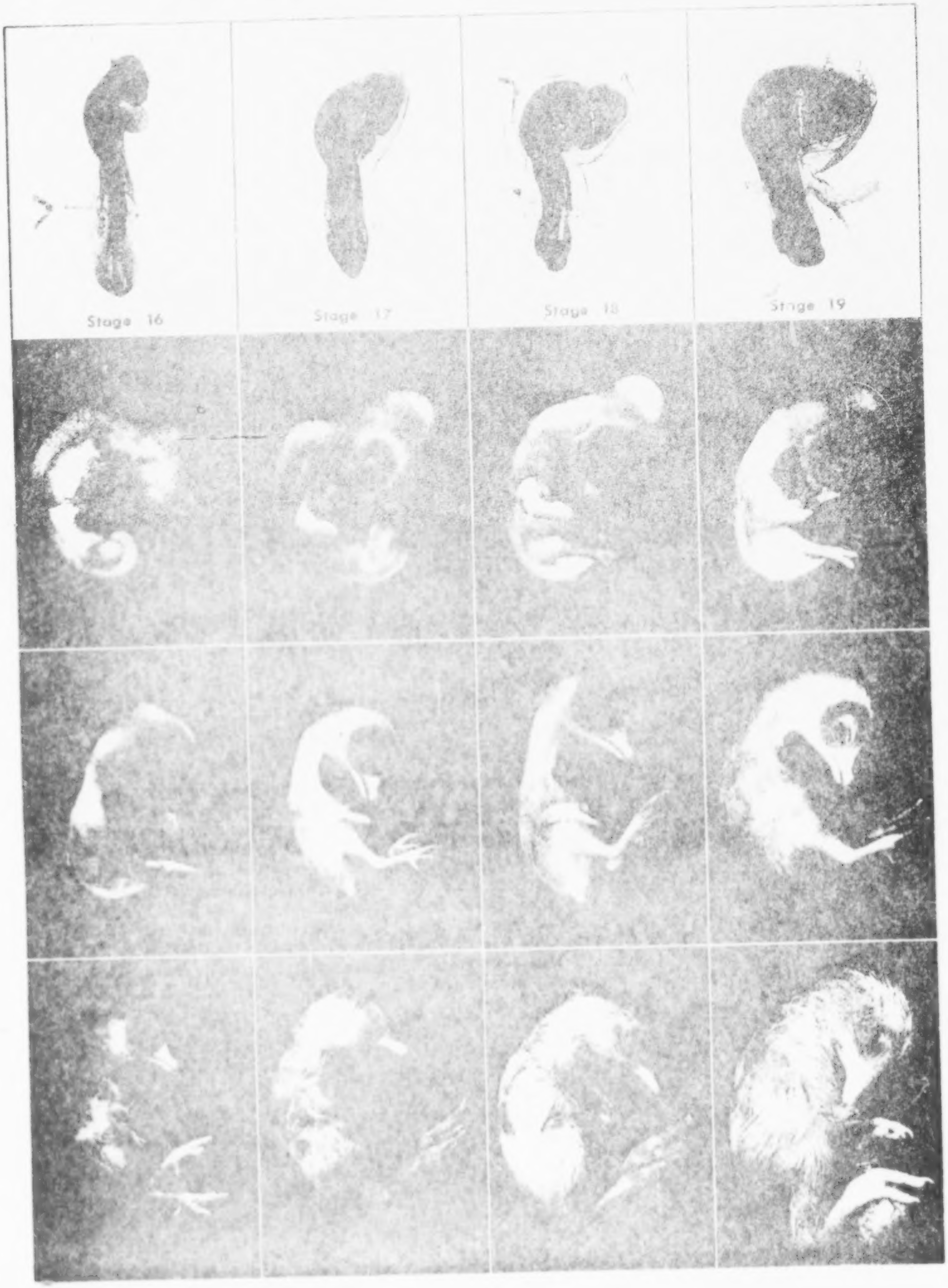
Figure 1: Removal of eggshell and albumen for study of the study of the chick embryo.



1. Using only the tips of the scissors break through the shell and carefully clip off the top.
2. Remove the cut piece with forceps and discard it.
3. Draw off the albumen with a dropper until the yolk surface is uncovered.

QUESTIONS:

1. From your observations, which system is the first to come into being?
2. What other systems have an early development?
3. What are the functions of the membranes that develop around the chick embryo?
4. The chick embryo has a large supply of food in the form of a yolk. How do the embryos of higher animals, which do not have a yolk supply, get their nourishment?



Stage 16 Stage 17 Stage 18 Stage 19

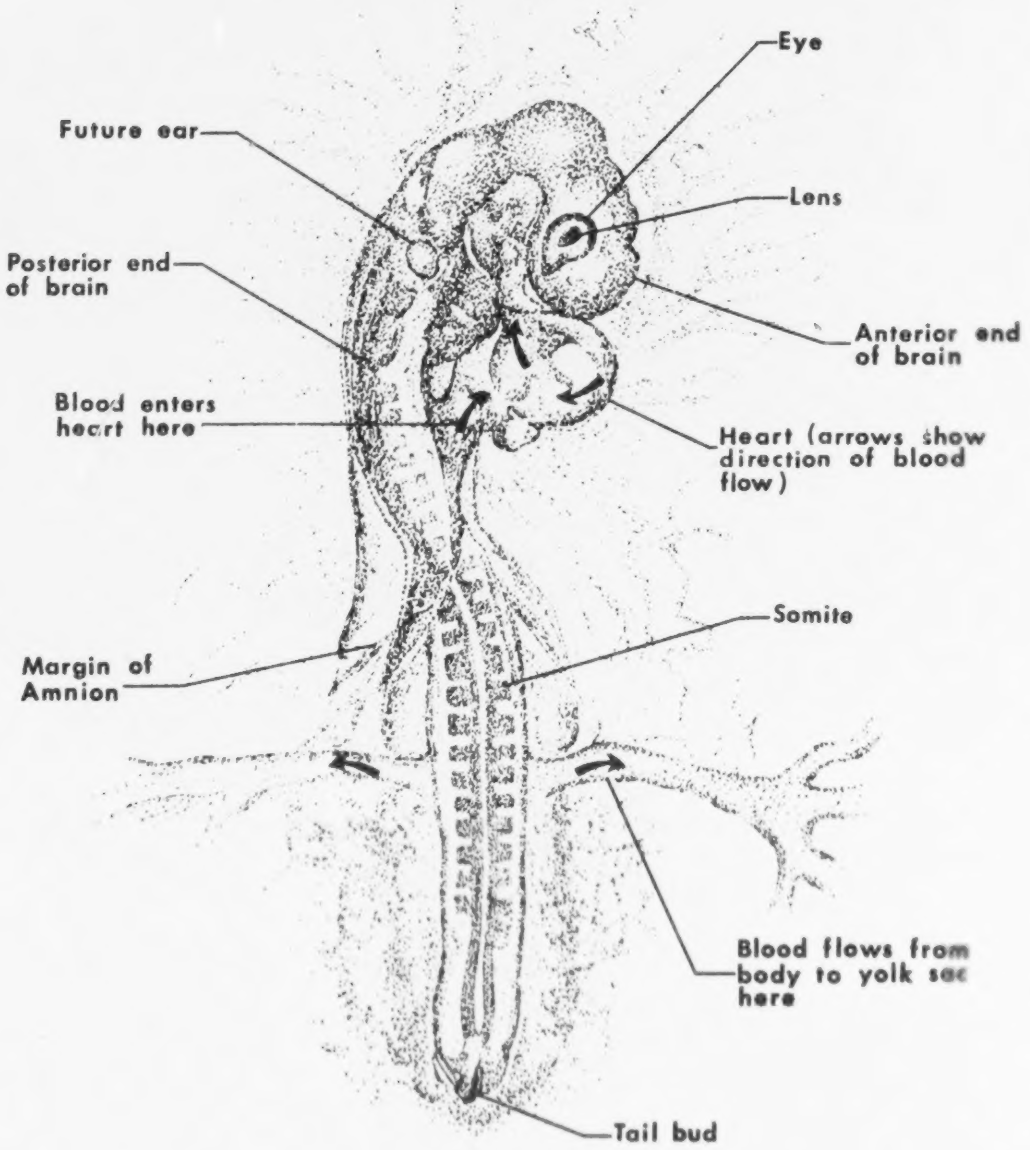

Eye
Future ear
Lens
Posterior end of brain
Anterior end of brain
Blood enters heart here
Heart (arrows show direction of blood flow)
Somite
Margin of Amnion
Blood flows from body to yolk sac here
Tail bud

FIGURE III–4. The chick embryo at 52 hours. This diagram shows several important changes that occur between 33 and 52 hours. The body of the embryo is now completed, and a tail is beginning to appear. The brain has bent around against itself, and the embryo is beginning to turn so that the anterior part is lying on its left side. A few hours later, the rest of the body will have rotated. The heart has been beating for about 12 hours at this stage, and there is a lively circulation of blood through the body and through the network of blood vessels on the yolk sac, which is now quite large. The vessels that carry blood into the heart are now concealed within the body, but we can see where the blood emerges from the body. The eye is very much further advanced than at 33 hours. The amnion, which will soon envelop the entire body, has covered the anterior end and is pushing on backward.

in of the yolk sac. When this event occurs, at about 19 days of incubation, the yolk sac is still quite large and, with the yolk it contains, may weigh 8 or 10 grams. This valuable food is not thrown away, but is drawn into the abdominal cavity where it can sustain the newly hatched chick for several days. The retraction is accomplished by rhythmical contractions of the abdominal wall which push the entire sac inside. The wall then seals itself shut at the navel.

Another sign of imminent hatching is that the chick pushes its beak into the air space at the big end of the egg. At this point the chick's own lungs can begin to function. The allantois, no longer needed, soon ceases to function; it will be left behind in the shell. After breathing air for a time, the chick *pips* the shell; that is, cracks a small hole in it. For this job, it uses a special tool, the *egg tooth*, a hard mass of calcium on the upper beak. When you actually look at embryos in the laboratory, see if you can tell when the egg tooth first appears. Soon after hatching, the tooth drops off the beak.

Altogether, the job of emerging from the shell takes about 24 hours. Several hours after the egg is pipped, the chick begins the struggle to enlarge the opening. The chick needs all its muscular power in this effort, but it uses especially a big strong *hatching muscle* at the back of its neck. This muscle gives the head the force it needs to break the hard shell. Like the egg tooth, the neck muscle is also a special tool; it too decreases in size once hatching has occurred.

If you are fortunate enough to be present when a chick finally emerges, you will see that the shell is completely split into two parts, and the chick wiggles free. At this moment, the chick is still wet from the amniotic fluid and lies limp, exhausted, and breathing hard on the incubator shelf. But in an hour or so it recovers nicely. The feathers dry and fluff out, the bright eyes open, and the little chick stands up on its sturdy feet and begins chirping in a tremendous voice. When you look at this lusty little hatchling, stop and reflect again that only three weeks before it was just a mass of yolk and egg white.

NOTE: To see a chick emerging from the shell, it is necessary to have an incubator with a glass door or cover. Hatching eggs should not be removed from the incubator.

C. Frog and Chick: Similarities and Differences

Vertebrate embryos in their early stages are very much alike in the way they are built and in the way they carry out the steps of their further development. If one compares the frog larva at about stage 18 or 19 (Figure I–2, page 6) with the chick embryo at 1½ to 2 days (Figures III–2 and III–4), one sees some striking similarities despite the superficial differences. In both one finds that the body contains a prominent tube widened at the anterior end into a brain; the narrower posterior part of the tube, which becomes the spinal cord, is flanked by a series of tissue blocks called *somites*. In both animals these somites develop into the backbone and its muscles and part of the skin. In both, the heart is a simple tube located below the brain. The bodies of both embryos end in a little tail, although neither animal has a tail as an adult.

The specimens that you study in the laboratory will give you only a suggestion of the resemblances between frog and chick. If you had the opportunity to study more stages, and to examine these stages in thin sections of embryos fixed and prepared for study under the compound microscope, you would see how deep-seated these resemblances really are. For example, you would find in the frog that the central nervous system (brain and spinal cord) arises as a flat neural plate, which rolls itself into a tube (Figure I–2, stages 13–15); the brain and spinal cord arise in just the same way in the chick embryo. In the 33-hour chick embryo, you are able to see that the eyes begin as a pair of outpouchings from the anterior end of the brain; sections of a stage 16–17 frog larva would reveal that the eyes are forming in exactly the same way. In both embryos, you would be able to see that the heart makes its debut as two separate parts which gradually come together in the mid-line and fuse to form the tube that becomes elaborated into the adult heart.

Again, you may have heard at some time that even a human embryo has gills or gill slits in early development. This is not exactly true; but all young vertebrate embryos do have along the sides of their heads a series of tissue masses separated from each other by deep clefts. In an aquatic form, like the frog, these masses produce gills; in nonaquatic forms, like the chick embryo or the human embryo, these same masses are present, even though they never form gills.

Stages in the normal development of the chick embryo. (See opposite

The stage numbers on these pictures are from the Hamburger-Hamilton stages, a series of 46 stages covering the entire development of the chick embryo from the time when the egg is laid (Stage 1) until the chick emerges from the shell (Stage 46). Embryologists use these stages as a guide in research.

Stage 16: About 52 hours. This is an embryo that was made transparent and then stained for detailed study under the microscope. At this stage, the anterior end of the body is resting on its left side. Referring back to figure 23, identify the eye, brain, heart, and somites. The skirtlike effect around the trunk is the posterior edge of the amnion, which is now being formed.

Stage 17: About 60 hours. The bending of the head against the trunk is continuing (compare with Stage 16). The amnion by now covers the body completely.

Stage 18: About 72 hours. The bending of the head is further advanced. The entire body now rests on its left side. The hindlimb buds are visible as thickened masses of tissue on each side of the body, just in front of the curled tail tip.

Stage 19: Between 3 and 3½ days. The tail tip has curled more than before. The dark mass in front of the tail is the allantois, which is just beginning to bulge out from the body.

Stage 21: About 3½ days. This is an embryo just removed from the shell and photographed by reflected light; all extra-embryonic membranes have been cut off. The body has now curved so much that the head and tail have come close together. Note how prominent the wing and leg buds have become.

Stage 25: About 4½ to 5 days. Notice the very large size of the head in relation to the rest of the body. The eye can be readily identified. The limb buds are developing elbow and knee joints.

Stage 30: About 7 days. The beak is beginning to appear near the lower edge of the head. A neck and trunk can now be clearly distinguished from each other. Toes are beginning to be marked out on the feet.

Stage 32: About 7½ days. The beak is now very distinct, as are the toes. Note that "fingers" are appearing on the wing bud, even though the chicken does not have any fingers in later life.

Stage 34: About 8 days. The small opening behind the eye is the ear. The "index finger" (no thumb is ever formed) is quite conspicuous.

Stage 37: About 11 days. Eyelids are now developing to cover the eyes. The legs are quite perfectly formed, even having claws on the toes. The skin is covered by prominent feather buds (some of these are present as early as 6½ days, but are not large enough to show up on the photographs).

Stage 38: About 12 days. Lengthening of the feather buds gives the embryo a more birdlike appearance. But note that the head is still very large in relation to the trunk.

Stage 39: About 13 days. The feathers are now well developed.

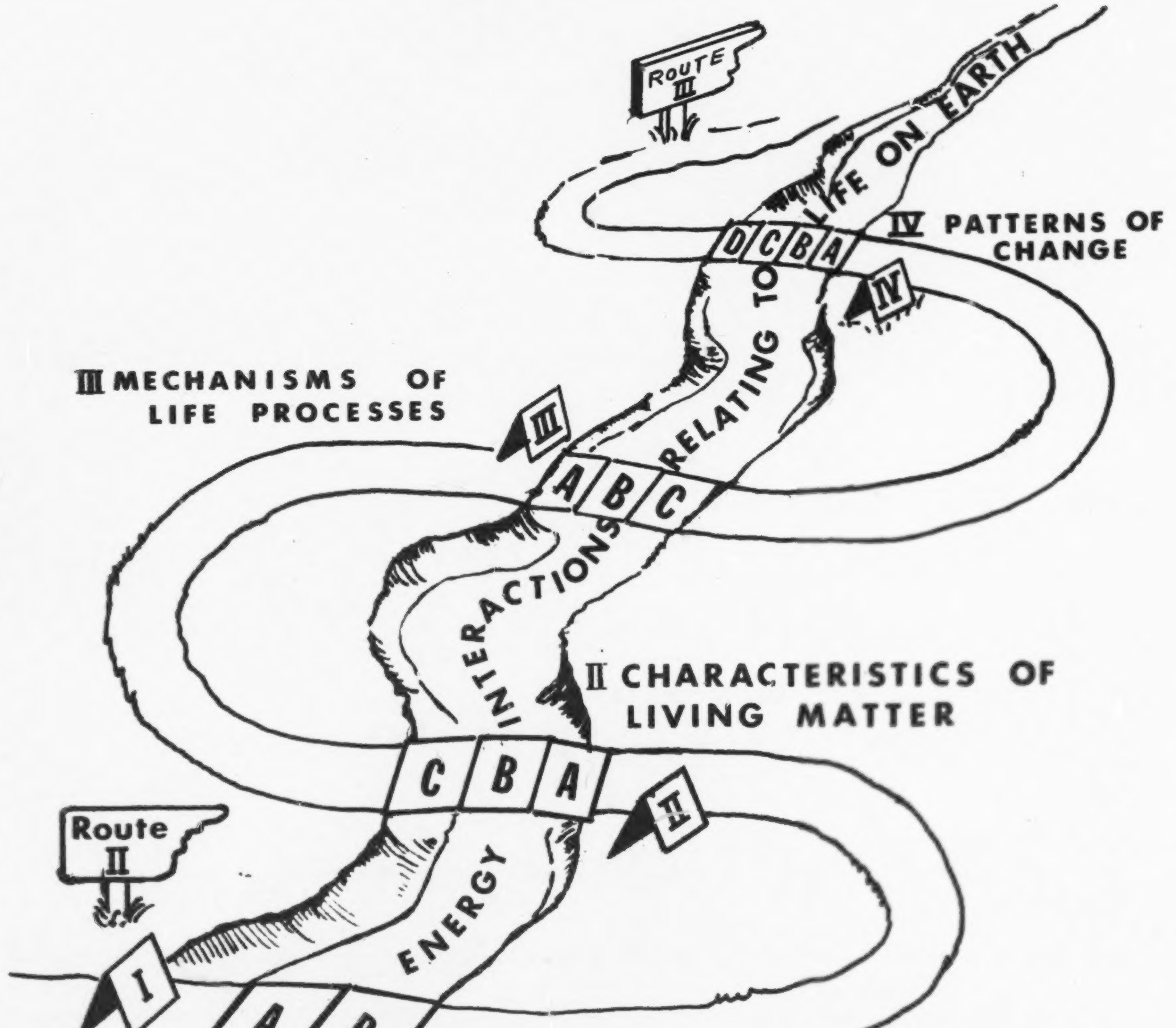
Stage 40: About 14 days. The eyelids are now big enough to cover the eyes completely.

Stage 42: About 16 days. As the chick grows, the body is increasing in size in relation to the head (compare with earlier stages).

Stage 44: About 18 days. The body proportions are becoming steadily more normal. Compare this stage with Stage 40 (14 days), and then contrast this 14–18 day interval with the interval between 3–7 days (Stages 18 and 30). Evidently changes occur much more rapidly early in development than in the later stages.

Stage 45: About 19–20 days. The chick has by now grown so much that it almost completely fills the shell. It is now ready to hatch. In preparation for hatching, the yolk sac has been drawn about half-way into the abdominal cavity.

SCIENCE IIA


ROUTE III
IV PATTERNS OF CHANGE
D C B A
IV
III MECHANISMS OF LIFE PROCESSES
III
A B C
INTERACTIONS RELATING TO LIFE ON EARTH
II CHARACTERISTICS OF LIVING MATTER
C B A
II
Route II
I
A B
MATTER-ENERGY
I EXPANSION OF IDEAS ABOUT THE NATURE OF MATTER

A. Heredity

B. Population Dynamics

C. Mechanisms for Evolution

D. Environmental Interactions

Heredity

MENDEL'S LAWS

Required Reading:	BSCS Yellow Version, pp 507-525 BSCS Blue Version, pp 329-353 BSCS Green Version, Chapter 16

I. The Life and Work of Gregor Mendel

   A. His Early Training

   B. His Combination of Botany and Mathematics

   C. His Lack of Recognition by Fellow Scientists

II. The Laws of Heredity Derived by Mendel

   A. The Law of Unit Characters

   B. The Law of Dominance

   C. The Law of Segregation

   D. The Law of Independent Assortment

III. The Vocabulary of Mendelian Genetics

A. Dominant Trait -

B. Recessive Trait -

C. Homozygous -

D. Heterozygous -

E. Allele -

F. Factor (Gene) -

G. Genotype -

H. Phenotype -

I. Hybrid -

J. Monohybrid Cross -

K. Dihybrid Cross -

MENDEL'S LAWS

The Secret of Life

A Reading

Genetics got its recognizable start, along with relativity, quantum theory and nuclear physics, during the scientific revolution of the early 1900s, but it had a strange, unpublicized start more than 40 years earlier when Gregor Mendel, an Augustinian monk and natural-history teacher in Brunn, (now Brno, Czechoslavakia), began experimenting with peas in the monastery garden. Mendel found that the parent plants transmitted their characteristics to their descendants in a predictable, mathematical way. When purebred red-flowered peas, for instance, are crossed with white-flowered ones, all the seeds grow into plants with red flowers. But when these red hybrid plants are crossed with each other, one-fourth of their offspring bear white flowers.

Mendel concluded that the reproductive cells of peas contain factors (now called genes) of two kinds: dominant and recessive. The gene for red-floweredness is dominant; the gene for white-floweredness is recessive. When red- and white-flowered plants are mated, the seeds produced get both genes, but the dominant red gene suppresses the recessive white gene. Result: red flowers in the first generation.

The white-flowered gene, though suppressed, is still in existence. When red hybrid flowers are mated together, each seed in the second generation has a one-in-four chance of inheriting nothing but white-flowered genes. It will then bear white flowers, just as if its parents were of pure, white-flowered stock. The other three-fourths of the seeds will bear red flowers.

Here was one of those extraordinary simplicites that can revolutionize a whole field of science. Mendel's observations proved that inside the cells of plants - and presumably animals too - is a mysterious mechanism, incredibly small, that rules heredity in accordance with precise mathematical laws. In 1866 Mendel published a paper to this effect in the proceedings of the Brunn Natural Science Society, but nothing happened. The world was not ripe for his ideas. In 1868, when he was appointed abbot of his monastery, his scientific career came to an end.

At the turn of the century, three scientists (Hugo De Vries in the Netherlands, Karl Correns in Germany, and Erich Tschermak in Austria) independently rediscovered Mendel's principles. They also rediscovered his long-forgotten paper, and gave him full credit; the basic principles of genetics are still known as Mendel's laws. Genetics, born at last to science's estate, went to work on the interwoven mysteries of life and heredity.

Gregor Mendel

KEY CHROMOSOMES. For a while, as often happens after a scientific breakthrough, additional discoveries came easily. Several biologists, notably Walter S. Sutton in the U.S., connected Mendelian inheritance with the known behavior of chromosomes, which are threadlike bodies in the nuclei of cells. When a cell divides nonsexually, as in a growing plant or animal tissue, the chromosomes replicate (make copies of) themselves. Each daughter cell gets a full set, and unless something has gone wrong, it is exactly like the chromosome set of the parent cell.

In sexual reproduction, the chromosomes behave differently. The sex cells (sperm and egg) are the end results of a complicated process (meiosis or reduction division) that gives each of them half as many chromosomes as in the nonsexual cells. This reduction is necessary because the sex cells join during fertilization of the egg, and if each contributed a full set of chromosomes, the fertilized egg would have twice the normal number. But if both sperm and egg contributes half as many chromosomes, the fertilized egg gets just the right number.

Many years before the birth of the science of genetics, the chromosomes had been observed behaving in this way, but no one knew why they did. Genetics supplied the answer. Reduction division is a kind of lottery that deals the fertilized egg half a set of chromosomes from each parent, like cards dealt out to players in a two-handed card game. When maternal and paternal chromosomes are slightly different, which is generally the case, their dominant genes (units of heredity) suppres recessive genes, as Mendel's red-flowered peas suppressed white-floweredness. Each recessive gene is still riding its chromosome, and biding its time in obscurity. It can assert itself only when the corresponding gene from the other parent is also recessive. It may have to wait for many generations (in the case of humans, for hundreds of years) before it gets its innings. Then, free of suppression by a dominant gene, it produces a white-flowered plant or a blue-eyed baby. Or, if it is a bad gene, it may produce a deformed baby or a plant that bears no flowers.

From Time, July 14, 1958

MENDEL'S LAWS, Cont.

SURVEY EXERCISE

Genetics

Survey Instructions: The following statements relate to various genetic principles, many of which are associated with common false ideas and superstitions. Certain of the statements are true. Others are false. The purpose of the survey is not to test you, but to provide a survey for you to use. Select three or more people of various ages and read each of the 20 statements. Ask each person if he believes the statements to be true or false. Tabulate the answers given after each statement and show the total number of subjects who responded to each statement. Be careful not to indicate the answer in reading the statement.

	True	False	Total
1. Certain acquired characteristics, such as mechanical or mathematical skill, may be inherited.			
2. Identical twins are always of the same sex.			
3. Fraternal twins are more closely related to each other than to other children in a family.			
4. The father determines the sex of a child.			
5. Each parent contributes half of a child's genetic make-up.			
6. Certain thoughts or experiences of a mother may mark or alter the hereditary makeup of an unborn child.			
7. Color-blindness is more commin in males than in females.			
8. A person may transmit characteristics to offspring which he, himself, does not show.			
9. Certain hereditary characteristics are influenced by the blood.			
10. Identical twins are more closely related than fraternal twins.			
11. Certain inherited traits may be altered by the stars, moon, or planets early in development.			
12. Males are biologically stronger than females.			
13. The tendency to produce twins may run in families.			
14. A craving for a food such as strawberries may cause a birthmark on an unborn child.			
15. Many of a person's inherited traits do not appear.			
16. The parent with the stronger will contributes more to a child's inheritance than the other parent.			
17. If a person loses a limb in an accident, it is likely that he or she will have a child with a missing limb.			
18. The attitude of parents toward each other influences the emotional makeup of an unborn child.			
19. Children born to older parents usually lack the vitality of those born to younger parents.			
20. The total number of male births exceeds female births each year.			

Survey Results

Tabulation Sheet

GENETICS

Correct answers to all survey statements are given below. Indicate the correct and incorrect answers on your survey. Then fill in the following table, giving results for the entire class. Using a sheet of graph paper, make a bar graph showing the percent of correct and incorrect responses to each of the questions in the survey. Use different colors to distinquish correct and incorrect responses. Number the 20 survey questions along the bottom of the graph and use the vertical graduations to indicate the percentage of correct and incorrect responses.

	No. correct answers	*No. incorrect answers*	*Total responses*	*% correct answers*	*% incorrect answers*
1. False					
2. True					
3. False					
4. True					
5. True					
6. False					
7. True					
8. True					
9. False					
10. True					
11. False					
12. False					
13. True					
14. False					
15. True					
16. False					
17. False					
18. False					
19. False					
20. True					

MENDEL'S LAWS, Cont.

Genetics Problems: Diagramming Crosses
Illustrating Mendel's Laws

INTRODUCTION:

I. Rules for Diagramming Crosses.

A. For dominant trait use first letter of term to describe trait and capitalize the letter. (eg. T = tall plant dominant to short plant.)

B. For recessive traits use same letter as for dominant trait but do not capitalize. (eg. t = short plant recessive to tall plant.)

II. Mendel's Data
(Monohybrid Cross, a cross for one trait)

P_1 Generation Phenotypes	F_1 Generation Phenotypes	F_2 Generation Phenotype Counts	Ratio of Phenotype Counts
Round x Wrinkled	Round	5,474 Round 1,850 Wrinkled	2.96:1
Yellow Seeds x Green Seeds	Yellow	6,022 Yellow 2,001 Green	3.01:1
Colored Seed Coat x White Seed Coat	Colored	750 Colored 224 White	3.15:1
Smooth Pod x Constricted Pod	Smooth	882 Smooth 299 Constricted	2.95:1
Green Pod x Yellow Pods	Green	428 Green 152 Yellow	2.82:1
Axial Flowers x Terminal Flowers	Axial	651 Axial 207 Terminal	3.14:1
Long Stem x Short Stem	Long	787 Long 277 Short	2.84:1

PROBLEMS

1. What letters would you use to describe the following traits involving garden peas?

_____tall

_____terminal flowers

_____colored

_____round

_____green

_____short stem

_____yellow

_____white seed coat

_____smooth

_____yellow pod

_____axial

_____green seeds

_____wrinkled seeds

_____constricted (rough) pod

2. How many factors (genes) for stem length does the garden pea have?

3. How many letter combinations are possible if one considers one pair of genes or factors? (stem length in peas for example)

Write out the combinations below:

4. What gametes are possible from these combinations?

TT Tt tt

5. Does it make any difference whether the gametes are male or female?

6. Diagram a cross between two "pure" yellow seed plants. Describe the phenotype of the F_1 generation.

7. Diagram a cross between two "pure" plants with round seeds. Describe the phenotype of the F_1 generation.

8. Diagram a cross between a pure tall plant and a pure short plant.

P_1 TT x tt

(gametes ___ ___ ___ ___ (recall what happens in meiosis or reduction division)

F_1 ______________________________

Describe F_1 offspring (phenotypes), - what term can we use to desbribe this gene combination?

9. In humans, brown eyes are dominant to blue eyes. Is it possible for two brown-eyed parents to produce a blue-eyed offspring?

METHOD OF DIAGRAMMING CROSSES - The Punnett Square

Example of a Monohybrid Cross

P_1 aa x AA

Female Gamete Possibilities
(genes)

Male Gamete Possibilities
(genes)

	A	A
a		
a		

NOTE: The F_1 generation is within the boxes of the Punnett Square

10. Allow the F_1 plants from problem #8 to "self-pollinate" - use the Punnett Square to show the results of this cross.

a. How many different genotypes are possible? ______________

b. List the genotypes possibilities. ______________

c. How many phenotypes are possible? ______________

d. What is the genotype ratio? ______________

e. What is the phenotype ratio? ______________

MONOHYBRID CROSSES: (Crosses involving only one trait)
NOTE: check Problem #1 for letters for genes.

11. Show the results of crossing a pure yellow-seed pea plant with a hybrid yellow pea plant:

F_1 genotype ________________ ratio ________________

F_1 phenotype ________________ ratio ________________

12. Cross a homozygous terminal (end) flower pea plant and a heterozygous axial (side) pea plant:

F_1 genotype ________________ ratio ________________

F_1 phenotype ________________ ratio ________________

13. Cross a female pure (homozygous) black guinea pig with a male pure (homozygous) white. (black is dominant)

F_1 genotype ________________ ratio ________________

F_1 phenotype ________________ ratio ________________

14. Outline a possible cross to determine whether a black guinea pig is homozygous or heterozygous for the coat color trait. Use the Punnett Square and show the P_1 genotype

P_1 genotype ________________ x ________________

DIHYBRID CROSSES: (Crosses involving two pairs of characteristics or traits resulting in individuals possessing mixed genes for both characters.)

Example of a Dihybrid Cross

P_1 Phenotype:	Pure (Homozygous) Round and Yellow Seeds Pea Plant	x	Pure (Homozygous) Wrinkled and Green Seeds Pea Plant
P_1 Genotype:	RRYY	x	________________ (fill in genotype)
P_1 Gametes:	RY		________________ (fill in gametes)

F_1 Phenotype: ____ (word description

F_1 Genotype: ________________________________ RrYy (dihybrid)

15. Utilize the Punnett Square and show the various types of seeds that can result if the F_1 genotype in the above example is allowed to self-pollinate.

F_1 "selfed" RrYy x RrYy

(female part of flower)

(male part of flower)

	RY	Ry	rY	ry
RY				
Ry				
rY				
ry				

The generation in the boxes of the Punnett Square are called the second filial generation or F_2 for short.

Note that in this cross involving two pairs of traits, of the 16 possibilities of gamete combination:

________________ of the offspring have seeds that are round and yellow
(give the number) (both dominant traits)

________________ have seeds that are round and green (one dominant and one recessive trait)

________________ have seeds that are wrinkled and yellow (the one dominant and the other recessive trait)

________________ has seeds that are wrinkled and green (both recessive traits)

The phenotype ratio to be expected is ___;___:___:___.

This illustrates another of Mendel's Laws:

THE LAW OF INDEPENDENT ASSORTMENT - where the separation of gene pairs on a given pair of chromosomes and distribution of the genes to gametes during reduction division (meiosis) is entirely independent of the distribution of other gene pairs on other pairs of chromosomes.

When Mendel made a cross similar to the one in Problem #5 he obtained the following results:

F_2
315 Round - Yellow
108 Round - Green
101 Wrinkled - Yellow
32 Wrinkled - Green

Do the actual results (as recorded by Mendel) agree with the expected results (Problem #15)? Hint: Check on the phenotype ratios.

INCOMPLETE DOMINANCE:

Consider Snapdragons - Pure Red - rr
Pure White - ww
F_1 (hybrids)- rw (neither red or white is dominate so the flower is pink)

16. What genotype and phenotype ratios are possible when two pink snapdragons are crossed?

17. The color of shorthorn cattle illustrates incomplete dominance. How can a farmer breeding (crossing) a pure red bull and a roan (the heterozygous condition) shorthorn, get a pure white calf?

PROBABILITY

INTRODUCTION:

In forming his theory of heredity, Mendel made use of the mathematics of probability. This branch of mathematics was originally developed by persons interested in gambling--in games of chance. "Chance" is a term used to describe any situation in which the factors affecting the outcome are so numerous and (taken individually) so weak that we can never hope to determine a "cause." "Random" is another term that applies to such situations. "Choosing at random" is a common expression; it means choosing entirely by chance--which results in a completely impartial choice.

To understand genetics, we need to know something about the mathematics of probability. Furthermore, we need to know something about probability to understand the nature of modern science. For science deals largely (some scientists would say entirely) with probabilities--not with certainties. For example, the principles of probability are at work in the disintegration of radioactive atoms and in the collision of molecules in gases--as well as in the distribution of genes from one generation to the next.

PURPOSE:

This exercise provides an opportunity to work out experimentally two principles of probability that are important in genetics.

BACKGROUND INFORMATION:

The basic question in probability is: How often should we expect a particular event to occur in a given number of events? Notice that we do not say, "How often will it occur?" Of course, the gamblers who first worked out the mathematics of probability would have liked to know exactly when, for example, the ace of spades would appear in a given deal of cards. But the best that the mathematics of probability can ever do for gamblers or for scientists is to tell what expectation will least often be disappointed. In the language of gamblers, it gives us the "odds."

The simplest way to express probability mathematically is by means of fractions. A coin has two sides, distinguished as "heads" and "tails"; when tossed into the air, it may land on either of the sides. The number of possibilities is the denominator of the fraction. What is the probability that "heads" will come up when you toss the coin? In this question you are looking for one specific event; this is the numerator of the fraction. Thus, the probability of a coin's landing "heads" up is 1/2. Of course we can write this as 0.5 or 50 percent, but the common fraction is the starting point.

Let us use this mathematical notation in some further examples: There are 52 cards in a deck (not counting the joker), 13 of each suit. What is the probability that you will draw a spade from a shuffled deck? There are 52 possibilities in the deck, of which 13 meet the conditions of the question. Therefore the probability is 13/52, 1/4, or .25, or 25 percent. What is the probability that you will draw the ace of diamonds? Again there are 52 possibilities, but this time only one meets the conditions of the question; the probability is 1/52. A die (singular of "dice") has six sides. What is the probability that a 5 will come up on one throw of the die? The probability is 1/6. What is the probability that an even number will come up on one throw of the die? Since there are 3 even numbers on the die--2, 4, and 6--there are 3 ways in which the conditions of the question may be met; therefore the probability is 3/6, or 1/2--the same probability as that of obtaining "heads" on one toss of a coin.

PROCEDURE:

In this exercise you will work in pairs--Student A and Student B

Part I.

A. Tossing a Single Penny - Use the LAB DATA SHEET for Recording Data

Toss a penny into a cardboard box ten times. Tally the result on the report sheet which follows. After the tenth toss, draw a line across the columns of the score sheet and reverse roles with lab partner, making sure each toss is tallied. Draw a line once again after the tenth toss. Continue reversing roles until the results of one hundred tosses have been tallied.

B. Tossing Two Pennies Together

Choose two pennies that can be easily distinguished--one dull and one shiny. Toss both pennies together twenty times. Tally the results on the form shown on the LAB DATA SHEET which follows. Reverse roles once. Then total the results from the entire class on the chalkboard.

Part II. Studying the Data: Answer all questions on Data Sheet

A. Tossing a Single Penny

1. What does the mathematics of probability (see "Background Information") lead you to expect in a series of ten tosses of the coin?
2. In any set of ten throws did you ever obtain the expected results? If not, how close did you come?

   Deviation is a measure of the difference between expected results and actual (observed) results. To calculate deviation, first determine the difference between the number of "heads" you expected and the number of "heads" you observed. Then determine the difference between the number of "tails" you expected and the number of "tails" you observed. Add the two differences together, and divide the sum by the total number of tosses.

   Calculate the deviation for each set of ten throws. Then add the results from one hundred tosses and calculate the team deviation. Finally, add the results from all the teams and calculate the class deviation.
3. How does increasing the number of tosses affect the size of the deviation? You have just worked out an important principle of probability.

B. Tossing Two Pennies Together

4. Consider "heads" on the dull penny; in how many columns does this appear?

5. In what fraction of the total number of tosses did "heads" appear on the dull penny?

6. In how many columns does "heads" on the shiny penny appear?

7. In what fraction of the total number of tosses did "heads" appear on the shiny penny?

8. In how many columns does "heads" on both pennies appear?

9. In what fraction of the total number of tosses did "heads" appear on both pennies?

10. In this fraction closest to the sum, the difference, or the product of the two fractions for "heads" on one penny?

You have just worked out a second important principle: the relationship between the probabilities of separate events and the probability of a combination of events.

APPLICATION:

11. Now assume that the shiny penny represents an egg cell. If it falls "heads" up, it represents an egg cell containing a recessive gene. Likewise assume (as did Mendel) that the combination of egg cells and sperms is a chance, or random, process. On the basis of these assumptions, what is the probability that a zygote will contain at least one dominant gene?

12. What is the probability that it will contain two recessive genes?

Laboratory Exercise

DATA SHEET

PROBABILITY

Part I

A. TOSSING A SINGLE PENNY

HEADS	TAILS

B. TOSSING TWO PENNIES TOGETHER

	BOTH H	DULL H/SHINY T	DULL T/SHINY H	BOTH T
Student A 20 tosses				
Student B 20 tosses				
TOTAL				

RESULTS FROM ENTIRE CLASS
TOSSING TWO PENNIES

ALL "A" STUDENTS				
ALL "B" STUDENTS				
TOTAL				

Part II. STUDYING THE DATA

A. TOSSING A SINGLE PENNY

1. ____________________

2. ____________________

3. ____________________

B. TOSSING TWO PENNIES TOGETHER

4. ____________________

5. ____________________

6. ____________________

7. ____________________

8. ____________________

9. ____________________

10. ____________________

11. ____________________

12. ____________________

Heredity

Name ____________________

Science IIA Hour _____

Date ____________________

MENDEL'S LAWS

Review Questions:

1. In what way do a sperm and an ovum contribute equally to a potential new individual?

2. In what way is the contribution of the ovum to a new individual different from that of the sperm?

3. Show how both heredity and environment contribute to the expression of a trait in animals, in plants, and in man.

4. Mendel planned his experiments with great perception. What features of his planning were important factors in his success?

5. Why did Mendel choose to perform his experiments with garden peas?

6. How did Mendel insure that his parent pea plants were pure for the traits he was observing?

7. What precautions must Mendel have taken to eliminate the variable effects of environment on the inheritance of the traits of the garden peas?

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8. What would the results be if RR plants were used to provide eggs while rr plants were used as pollen sources in a cross of two individuals homozygous for the given traits? Suppose this were reversed and the RR plants provided the pollen and rr plants the eggs? What is the significance of these two sets of results?

9. Why do experiments in genetics require large numbers of individuals for conclusions to be reasonably valid?

10. Among the following genotypes, which ones are heterozygous and which are homozygous? Which of the genotypes have the same phenotype (the capital letter stands for dominance)? Pick out from the list one or more genes for which only two alleles are given. Also pick out a series of multiple alleles.

AA. I^AI^B, ss Bb, I^Bi, Aa, BB, rr, ii

11. What is a test cross? How is it used to determine the genotype of an animal or plant of unknown gene makeup?

12. Describe three different ways in which two alleles may contribute to the phenotype of a heterozygote.

13. How can there be multiple allelic genes for a hereditary trait when a single individual can carry only two alleles of a gene? How do multiple alleles operate in the inheritance of blood type in man?

14. What would the results be of a cross of AaBbCc x AaBbCc in which three inherited traits were observed? Let A represent the dominant gene for short and a, the recessive to tall; B, the dominant gene for black and b, the recessive gene for white; C, the dominant gene for curly and c, the recessive gene for straight.

Laboratory Exercise

MENDEL'S LAWS

Study of Mendelian Laws

PURPOSE:

To study Mendel's laws of unit characters, dominance, segregation, and independent assortment.

The laws that Mendel formulated from his experiments with garden peas stand today, practically unchanged. His conclusions concerning the inheritance of traits were based on the study of many generations of garden peas. Since you cannot study several generations of plants or animals during your biology course, we have provided several situations in which you can study Mendelian laws of inheritance and determine the expected ratios of offspring from parents whose genotypes are provided.

Answer all questions on the lab sheet which follows.

Part 1. Monohybrid Cross. The seed coat was one of the seven pairs of contrasting traits that Mendel studied in garden peas. He found that some seeds had smooth coats and others had wrinkled coats. He crossed plants having these two types of seeds to determine how the seed coat trait is inherited.

MATERIALS: No materials or apparatus required.

PROCEDURE AND OBSERVATIONS: The parent plants in the cross Mendel used are shown in Figure 1. The plant that is homozygous for smooth seeds is designated as SS, while ss indicates the genes in the plant that is homozygous for wrinkled seeds.

a. If the male parent is homozygous for smooth seeds, what kind of gene will be present in each sperm produced?

b. Similarly, if the female parent is homozygous for wrinkled seeds, what kind of gene will the eggs contain? Diagram this cross in the Punnett square marked F_1.

c. What is the genotype of the plants in the F_1 generation?

d. What is the phenotype of the plants in the F_1 generation?

e. How does this cross illustrate the law of unit characters?

f. Of dominance?

g. In what way do the offspring of the F_1 generation differ from the parents?

Mendel then crossed two heterozygous smooth-seed plants (Ss) to produce the F_2 generation. Diagram this cross in the Punnett square marked F_2 shown on the next page.

h. What is the phenotype ratio of the offspring?

	♂ Smooth seeds SS	♀ Wrinkled seeds ss
Female GENES Male		

F_1

Figure 1.

(Continued on next page)

i. What two kinds of smooth-seed plants are present in the F_2 generation?

j. Which of Mendel's laws are demonstrated in this cross?

	♂ Hybrid smooth	♀ Hybrid smooth
Female GENES Male		

F_2

Part 2. Dihybrid Cross. In Part 1 you diagrammed the inheritance of a single trait. In this Part you will study crosses in which two traits are involved.

MATERIALS: No apparatus or materials required.

PROCEDURE AND OBSERVATIONS: In the P generation shown in Figure 2, the male parent is black and rough-coated and is homozygous for both of these characters (BBRR). Black and rough are dominant in guinea pigs. The female parent is a homozygous white, smooth-coated guinea pig (bbrr). Both of these characters are recessive.

a. What genes are in the sperm?

b. What genes are in the eggs?

c. What is the genotype of the F_1 generation?

d. What is the phenotype of the F_1 generation?

Two of the offspring of the F_1 generation are used as parents to produce the F_2 generation in Figure 2. Diagram the possible offspring from such a cross in the Punnett square and list the ratio of the four phenotypes below the Punnett square.

e. How does this cross illustrate the law of independent assortment?

f. If the genes for coat color and those for coat texture were carried on the same chromosome, would this law apply? Explain your answer.

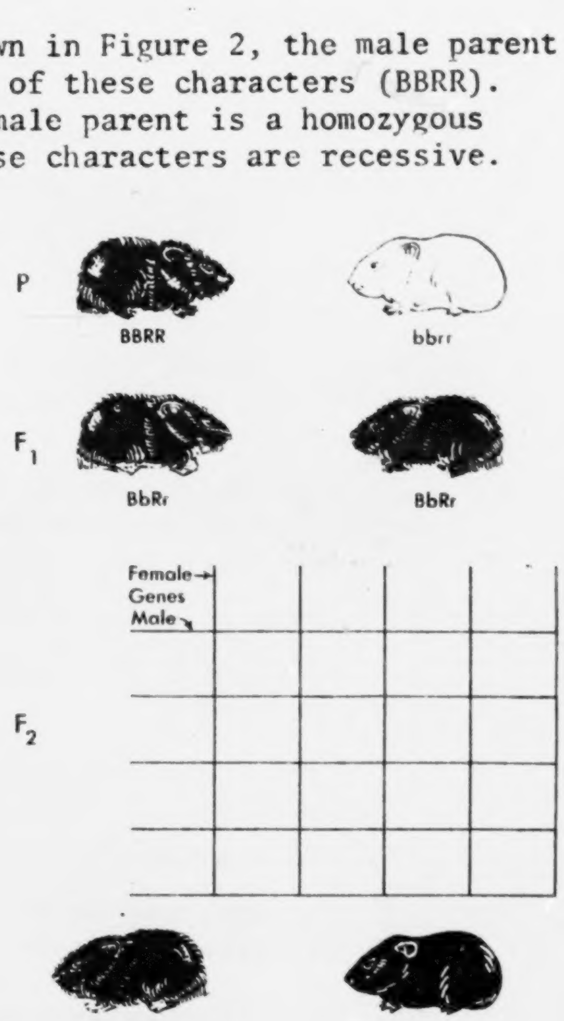


Figure 2. A cross involving two pairs of genes with dominance

Ratios

Black rough ..... White rough .....

Black smooth ..... White smooth .....

Part 3. Study of Inherited Traits in Corn Seed. There are two very striking contrasting inherited characteristics found in corn seeds. One is the color of the outer layer of the endosperm (purple or nonpurple) and the other is the characteristic of the seed coat (smooth or wrinkled). When pure strains of corn producing purple seeds are crossed with pure strains of corn producing nonpurple seeds, all of the F_1 offspring have purple seeds. Furthermore, when pure strains of corn producing smooth seeds are crossed with pure strains producing wrinkled seeds, all the F_1 offspring have smooth seeds.

MATERIALS: Genetic corn showing a 1:1 ratio of colored-colorless seeds (purple-yellow); genetic corn showing a 3:1 ratio of colored-colorless seeds (purple and yellow); genetic corn showing a 9:3:3:1 ratio purple-smooth-yellow-shrunken seeds; straight pins.

PROCEDURE AND OBSERVATIONS: Section 1 Monohybrid cross. Some of the members of the class will be given ears of corn that were produced by crossing two hybrid purple parent strains; others will received ears that were produced by crossing a hybrid purple parent strain and a nonpurple parent strain. You will not be told what kind of cross produced the ear of corn you have. You must determine this for yourself by counting the number of kernels of each color (purple or yellow) you find on the ear. Put a pin in the end of the row of kernels when you begin the counting. Count the characteristics of each kernel in a row until you return to the point marked by the pin. Record your count in the table provided on the Lab Report Sheet. Do not pick the kernels from the ears.

Determine the total number of purple and nonpurple seeds you have on your ear of corn. Record the total in the table provided on your answer sheet.

a. What percent of the seeds were purple?

b. nonpurple?

c. What is the ratio of purple to nonpurple seeds?

d. Is there any evidence of purple color in the nonpurple seeds?

e. Explain your answer.

f. The purple seeds on both kinds of ears of corn that members of the class have counted resemble one another in color, what evidence did you find that they may differ genetically?

g. List the Mendelian laws illustrated in this Part.

Interpretation: One the basis of your results, reconstruct the genetic makeup of the parents of the two kinds of ears of corn.

Section 2 A dihybrid cross. You will not be told what kind of plants were crossed to obtain the ear of corn you have. Your counting of the characteristics (purple, nonpurple, smooth, and wrinkled) should help you determine the possible genotypes of the parents. Use the same procedure as was used in Section 1 of this Part to count and classify the seeds. Record your count in the table provided.

h. How many different phenotypes did you find?

i. Name these types.

j. Which type appeared most frequently?

k. less frequently?

l. Were the purple wrinkled seeds as common as the nonpurple smooth ones?

m. Using the symbols P for purple and p for nonpurple and S for smooth and s for wrinkled, give the genotypes of the F_1 generation that produced the ear of corn you examined.
The two parents that produced the F_1 Generation were pure strains.

n. Give the genotypes of the parents of the F_1 generation.

o. Which Mendelian law is represented in this section?

Interpretation: On the basis of your results, explain how genetic principles operate according to predictable rules.

Part 4 Study of Inheritance of Size in Peas. THIS WOULD BE A GOOD RESEARCH PROJECT.

Problem. How is height inherited in pea plants?

Gregor Mendel determined that the gene for tallness in pea plants was dominant over the gene for dwarfness. You can duplicate his work by using tall and short peas of known genetic strain as parent plants and producing an F_1 and F_2 generation under controlled experimental conditions.

Suggested Materials. Twenty-four little Marvel or Progress #9 strain seeds homozygous for dwarf plants; 24 Alderman variety homozygous for tall pea plants; flats for planting seeds; 4-5 inch flowerpots; potting soil; supports for tall plants; forceps; string.

Suggested Procedure. Obtain seeds for both dwarf and tall pea plants from your teacher. Plant the two types of seeds three inches apart in germinating flats so that they are covered by one inch of soil. Put the flats near a window. You may put them outside if the temperature is not too low. Water as needed. After five to ten days, select 12 of the most vigorous plants of each type and plant them in 4-5 inch flowerpots. (You can determine which plants are dwarf ones after the five- to ten-day interval.) Provide the tall plants with some type of support.

Cross-pollinations will have to be done before the flowers open. If you do not cross-pollinate the flowers before they open, the anthers will shed their pollen onto the stigma and self-pollination will occur. Remove the brightly colored portion of the flower to expose the stamens and pistil. The stamen consists of a slender stalk with a more or less cylindrical anther at its apex. Pollen grains, which are responsible for the production of male reproductive cells, or sperm, are contained in the anther. The pistil is found in the center of the flower. This is the female part of the flower; it contains the ovary, within which seeds are formed following fertilization by the sperm.

Use a pair of forceps to remove all the stamens from the plants. Then dust the pollen from an anther onto the tip of the pistil. Be sure to record the crosses you make and to clean the forceps each time you start to cross-pollinate a new set of flowers so as to avoid contamination of the stigmas with other pollens you have used.

Allow the plants to grow until pods have developed. After the pods have ripened, remove them carefully, being sure to label each one as to the type of cross producing it. Put all the pods from similar crosses into one container.

To determine what kind of plant each seed will produce, plant each seed as you did previously. Keep a record of where each seed is placed. After five to ten days record your data and determine whether the plants are tall or dwarf. These plants represent the F_1 generation. To produce an F_2 generation, cross F_1 plants in the same way that you crossed the parent plants. Plant the resulting seeds to determine the height ratio in the F_2 generation.

Analysis and Conclusions: Summarize your data in Punnett squares or in table form. Your study should result in an understanding of how Mendel's laws of unit characters, dominance, and segregation apply to the inheritance of height in garden peas.

LAB REPORT SHEET

Name ____________________

Science IIA Hour ____

Date ____________________

Study of Mendelian Laws

Part 1. Monohybrid Cross.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

i. ____________________

j. ____________________

	♂ Smooth seeds SS	♀ Wrinkled seeds ss
Female GENES Male		
F_1		

	♂ Hybrid smooth Ss	♀ Hybrid smooth Ss
Female GENES Male		
F_2		

Part 2. Dihybrid Cross.

a. ____________________

b. ____________________

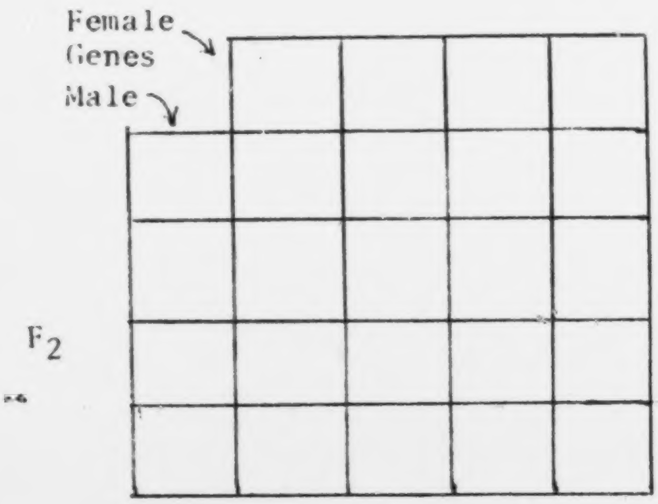
c. ____________________

d. ____________________

e. ____________________

Use Punnett square on next page.

f. ____________________



Part. 3 Study of Inherited Traits in Corn Seed

Section 1. Monohybrid Cross.

Record your count on this table.

Kind of Seeds	*Number in Each Row*												
	1	2	3	4	5	6	7	8	9	10	11	12	*Total*
Purple													
Nonpurple (Yellow)													

a. ______

b. ______

c. ______

d. ______

e. ______

______

______

f. ______

______

g. ______

______

Part 3.

Section 2. A dihybrid cross.

Record your count of this table.

Kind of Seeds	*Number in Each Row*												
	1	2	3	4	5	6	7	8	9	10	11	12	*Total*
Purple-smooth													
Purple wrinkled													
Nonpurple smooth													
Nonpurple wrinkled													

h.

i.

j.

k.

l.

m.

n.

o.

SUTTON'S HYPOTHESIS

Required Reading: BSCS Blue Version, pp 357-378, Ch. 16
BSCS Yellow Version, pp 527-547

I. The Year 1900 - Mendel is Discovered

A. DeVries - Carren - Tschermak

B. A Review of Mendel's Principles

C. Questions Unanswered by Mendel's Principles

1. Do hereditary "factors" really exist?

2. If these factors (genes) exist, where are they?

3. If these factors exist, do they comply with Mendel's Principles?

II. Sutton's Hypothesis Explains Mendel's Principles
(Walter Sutton - American Geneticist 1876-1916)

A. Sutton's Idea Resulted from Uniting Cytology with Genetics

B. Sutton's Argument - The Genes are in the Cell Nucleus

1. Genes must be located within gametes

2. Egg + Sperm contribute equally in heredity

3. Sperm is mostly nucleus. Therefore genes are in the nucleus

C. Sutton Observed Chromosome Activity During Meiosis and compared it to Mendel's "factors".

D. Sutton's Hypothesis

III. Scientific Evidence Supporting Sutton's Hypothesis

A. Thomas Hunt Morgan, American Geneticist, 1866-1945.

1. Morgan's Use of a New Biological Tool - Drosophila

2. Determination of Sex in Drosophila

3. Morgan's Analysis of Sex linked inheritance using eye color.

B. Calvin B. Bridges, American Geneticist, 1889-1938

1. An exception to the rule of inheritance of eye color

2. Non-disjunction as explanation for this exception.

IV. The Concept of the Gene Today

Laboratory Exercise

SUTTON'S HYPOTHESIS, Cont.

Chromosomes and Genes

PURPOSE:

To study the chance distribution of genes in eggs and sperm resulting from meiosis during oogenesis (egg formation) and spermatogenesis (sperm formation) and to study the salivary glands of the fruit fly.

The study of genetics reveals that hereditary traits are determined by specific areas of a chromosome called genes. Genes are arranged in linear order on the chromosome and occur in pairs, as do the chromosomes. Chance distribution of chromosomes during meiosis and their recombination during fertilization account for the many variations that occur in offspring.

Part 1. Demonstration of the Chance Combination of Genes During Fertilization.

In this Part you will study the random, or chance, combination of two kinds of beans. There are only three possible combinations these beans can make. This represents what actually occurs during fertilization when a gene pair lying on two homologous chromosomes recombines after being separated during meiosis.

MATERIALS:

eight boxes; 1,600 red beans; 1,600 white beans

PROCEDURE AND OBSERVATIONS.

The class should be divided into four sections for this activity. Each section will have two boxes of beans. Each box contains 400 red beans and 400 white beans. Label one box to represent the genes contributed by the sperm and the other to represent genes contributed by the egg.

Since the egg and the sperm each contribute one gene of a single pair, choose a bean from each box in order to have a gene pair. Lay the gene pairs in rows: red-red, red-white, and white-white. Select your beans in a series of rounds which will be timed by your teacher. After each round, count the beans in each row and record in the table provided on the Lab Report Sheet which follows.

On the basis of the data you collected, it is possible to calculate the ratios for each type of gene pair. Add the totals of your three rows and divide the sum by four. (The four represents the reduction that occurs in the formation of the egg and sperm during meiosis.) Then divide the quotient into the total for each row. The number you obtain expresses a ratio. A sample of this calculation is shown at the right.

$37 + 86 + 41 = 164$

$164 \div 4 = 41$

$37 \div 41 = .9$

$86 \div 41 = 2.1$

$41 \div 41 = 1.0$

Ratio .9 red-red
2.1 red-white
1.0 white-white

Place your answers on the Lab Report Sheet.

QUESTIONS:

1. What ratio did you obtain?
2. Why is it necessary to have so many beans in each box?
3. Explain why the number of each color is constant in all boxes.
4. Why was it necessary to select so many pairs?
5. What were your chances of selecting the same color of beans in a gene pair?
6. A different color?
7. Explain why it was important to use two different colors?
8. What genetic principles are demonstrated by your bean selection?

Interpretation. How does chance selection of genes provide the basis for variations in organisms?

Laboratory Exercise

Part 2. Study of Salivary Chromosomes in Drosophila.

The salivary glands of the fruit fly are made up of giant-sized cells with unusually large chromosomes. Because of their size, these chromosomes have been used extensively in genetic studies. In this Part you will be given the technique for dissecting, staining, and studying the salivary chromosomes of the fruit fly.

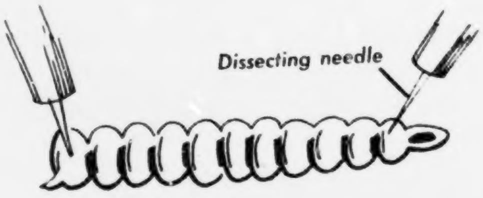
MATERIALS:

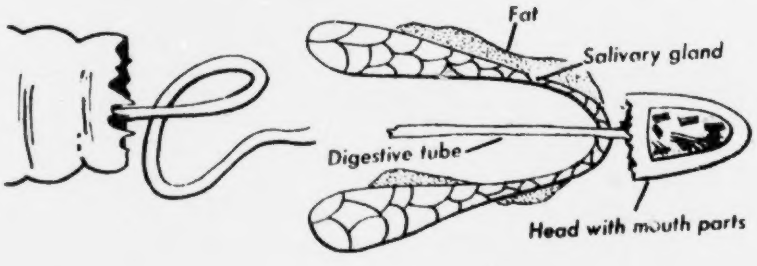
- culture of fruit fly larvae
- microscope
- slides
- cover glasses
- dissecting needle
- forceps
- paper towels or filter paper
- carmine powder
- 45% acetic acid
- 0.7% sodium chloride solution

PROCEDURE AND OBSERVATIONS.

Study the fruit fly larvae in the container on your desk and locate the largest one. Insert a pair of forceps and remove this larva. Put it on a slide and study it closely. Find the anterior end. It is pointed and you can see the black mouth parts as they move back and forth.

Now put a drop of 0.7% sodium chloride solution on the larva. Locate the head end and pierce it with a dissecting needle. The larva wiggles, and you will probably need to make several attempts before you finally pierce the head. Then pierce the posterior end and hold it down, as shown in the figure below. Slowly stretch the larva until the mouthparts tear off. You may need to sacrifice several larvae before you are successful.





After you have removed the mouthparts, mount them on a clean slide and examine them under low power of the microscope. Compare your material with the sketch shown. Now free the glands from the digestive tube and push them to one side. Remove any other parts of the larva.

Use filter paper or a small piece of paper toweling and remove the excess salt solution around the glands. Avoid touching the glands.

Staining the salivary glands will enable you to see the chromosomes better. Acetocarmine is the preferred stain because it differentiates the nucleus. The procedure for preparing acetocarmine is as follows: To a boiling 45% acetic acid solution add carmine powder until the solution is saturated. Then filter the solution.

Place one drop of acetocarmine stain on the salivary glands. Observe the action of the stain under the low power of the microscope. Allow the stain to stand for five minutes. Put a piece of paper toweling around your thumb to soak up the stain. Now carefully placd a plastic cover glass on top of the stained glands and press it down gently with your thumb. Examine the slide under the microscope.

Place your answers on the Lab Report Sheet.

QUESTIONS:

1. What is the condition of the gland?

2. Can you identify the nucleus in most of the cells?
   Examine the nuclei and locate the coiled giant chromosomes.

   Focus very carefully and slowly on these chromosomes.

3. Can you see any structures in the chromosomes?
   Make a sketch in the space provided on the Lab Report Sheet of several cells and show all the structures you can see. Identify and label: nucleolus, nucleus, and chromosome bands.

Removing the chromosomes from the nucleus is a very difficult procedure. Remove the slide from the microscope stage and tap the cover glass very hard 10-20 times with the handle of the dissecting needle.

After you have tapped the cover glass, examine the slide under the microscope. You should find a nucleus which split and released the giant chromosomes. If you were not successful with the tapping, repeat the process and examine again. If you find a chromosome or a piece of one by itself, focus on it and look for its structures.

4. Describe the chromosome.

5. Can you locate the genes?

Interpretation. From your study of salivary chromosomes in Drosophila, discuss the characteristics of these chromosomes that make them ideal subjects for genetic study.

LAB REPORT SHEET

Name ______________________________

Science IIA Hour____

Date ___________________________

CHROMOSOMES AND GENES

Part 1. Chance Combination of Genes During Fertilization.

Round	Number of Pairs of Beans In:		
	Row 1 red-red	Row 2 red-white	Row 3 white-white
1.			
2.			
3.			
4.			

QUESTIONS:

1. ____

2. ____

____

3. ____

____

4. ____

____

5. ____

____

6. ____

7. ____

____

8. ____

____

Part 2. Salivary Chromosomes in Drosophila.

1.____

2.____

3.____

4.____

5.____

Interpretation:

Heredity

Name ______________________

Science IIA Hour ____

Date ______________________

SUTTON'S HYPOTHESIS

Review Questions.

1. What very basic assumption did Sutton make at the beginning of his work relating genetics and cytology?

2. What arguments did Sutton advance to support his basic hypothesis?

3. Why must a theory be constantly reviewed and possibly changed?

4. What organism and what experiments provided some "proof" for the chromosome theory of heredity?

5. How was Sutton's theory that genes are located on chromosomes tested?

6. What new aspect was added to the gene-chromosome theory as a result of Morgan's experiments with *Drosophila*?

7. What is a sex-linked trait? Give two examples

8. In terms of probability, why is color blindness so rare in women?

9. What kind of reasoning led to the idea that non-disjunction might occur?

10. How must Mendel's principle of independent assortment be modified in the light of present-day knowledge?

11. What is the genetic method for determining the relative distance between two genes on a chromosome?

12. What is a cytological method for determining the relative distance between two genes on a chromosome?

13. How does the proof of a scientific theory differ from that of a theorem in geometry?

14. Why was the publication of Bridges' results termed a "wedding of genetics and cytology"?

15. How was Mendel fortunate in his choice of traits to study in garden peas?

GENES AND GENETIC CONTINUITY

Recommended Film Strips: Investigations Into Bacterial Heredity
The Genetic Code

I. History of Ideas About Genetic Continuity

A. 1900-1910 - Development of the Ideas of Genetics

B. 1914-1940 - Discovery of the Mechanism of Heredity - the Chromosome and the Gene

C. 1940-1960 - Development of the Chemistry of Genetics

D. 1960-1970 - Refinements of the Chemistry of Genetics - Molecular Biology

II. The Major Ideas of Molecular Genetics

A. The Relationship of the Gene to DNA

B. The Nature of Molecular Control - the Genetic Code

1. The Codon

2. The Assembly and Linkage of Amino Acids into Proteins

3. How Proteins control Cell Functions and appearance

C. Change in Living Systems as Controlled by the Genetic Code

1. Regulatory Genes

2. The Molecular Basis of Mutation

3. The Virus Life Cycle

4. Chromosomae Abnormalities in Man

5. Nuclear Transplantation in the Vertebrates

THE GENETIC CODONS AND THEIR AMINO ACIDS

Amino Acid	Abbreviation	Codon Synonyms					
alanine	ala	GCU	GCC	GCA	GCG		
arginine	arg	CGU	CGC	CGA	CGG	AGA	AGG
asparagine	asp-NH_2	AAU	AAC				
aspartic acid	asp	GAU	GAC				
cysteine	cys-SH	UGU	UGC				
glutamic acid	glu	GAA	GAG				
glutamine	glu-NH_2	CAA	CAG				
glycine	gly	GCU	GCG	GGA	GGG		
histidine	his	CAU	CAC				
isoleucine	ileu	AUU	AUC	AUA			
leucine	leu	UUA	UUG	CUU	CUC	CUA	CUG
lysine	lys	AAA	AAG				
methionine	met	AUG					
phenylalanine	phe	UUU	UUC				
proline	pro	CCU	CCC	CCA	CCG		
serine	ser	UCU	UCC	UCA	UCG	AGU	AGC
threonine	thr	ACU	ACC	ACA	ACG		
tryptophan	try	UGG					
tyrosine	tyr	UAU	UAC				
valine	val	GUU	GUC	GUA	GUG		

There are 64 possible codons (nucleotide triplets) which encode 20 amino acids. There are 61 codons which specify these amino acids. Note that most amino acids have more than one codon (synonyms) but no single codon specifies more than one amino acid. The 3 codons which do not specify an amino acid act as chain terminating punctuation; these are UAG, UAA, and UGA. Codons which do not specify an amino acid are called nonsense codons.

GENES AND GENETIC CONTINUITY

Properties of Human Blood

INTRODUCTION:

The circulation of blood in the body was explained and demonstrated by William Harvey more than 300 years ago, but the blood components and their function are not yet completely understood. One of the most interesting aspects of blood composition is the question of blood groups. There are four human blood groups: A, B, AB, and O. Members of these groups are characterized by the presence or absence of certain specific proteins in the red blood cells. Members of the A group have protein A in their red cells; members of the B group have protein B in their red cells. In the AB group both proteins are present in the red blood cell, while in the O group neither A nor B proteins are present. Members of the A and B group are each further characterized by the presence of specific proteins in their blood plasma. The protein in A group plasma is called "anti-B" because it causes B group red cells to clump. Also, an "anti-A" protein is contained in B group plasma which causes A group red cells to clump.

PURPOSE:

In this exercise you will determine your own blood type. In addition, you can learn more about blood composition by examining a blood sample under the microscope.

PROCEDURE:

Answer questions on Lab Sheet which will be handed out.

Obtaining a Blood Sample: To prepare for blood grouping, mark a circle the size of a penny on each end of one side of a microscope slide. Using a glass marking pencil, mark the left-hand circle "A", and the other "B".

A FEW WORDS OF CAUTION are in order before you start the procedure of drawing a blood specimen. Follow directions precisely. Use only a sterile, disposable lancet and be certain to dispose of it immediately so that no other person can use the same lancet. This must be done to avoid infection. Your teacher will instruct you in the method of obtaining a blood sample.

Blood Grouping: Place a drop of blood in each of the circles on the slide. Then add a drop of anti-A serum to the A circle and a drop of anti-B serum to the B circle. Immediately mix the blood and serum in each circle, with a toothpick. Use a separate toothpick for each test. Observe the results.

1. What is your blood type?

2. What type of specific protein, if any, do you have in your blood cell?

3. Prepare a table showing the distribution of blood types in your class. Compute the percent of each of the four types: A, B, AB, and O.

4. Why is it important to know the blood types of both the donor and the recipient in a blood transfusion?

5. If the "wrong" type of blood is used in a transfusion, what is the effect on the circulatory system and on the rest of the body?

6. If you have correctly determined your blood group, people with what type or types of blood may safely receive your blood?

7. If your determination is correct, you may safely receive blood from people of which blood group or groups?

Laboratory Exercise

GENES AND GENETIC CONTINUITY

Classification and Heredity of Human Traits

INTRODUCTION:

A surprisingly large number of human characteristics, some of them quite inconsequential, have been found to be hereditary. The mode of inheritance of some of them is simple, in others it is complex; and in most instances the trait is modified by various environmental factors. In this investigation you will learn to classify a number of these characteristics, so that you can construct a pedigree showing how you yourself, your brothers and sisters, father and mother, and more remote relatives (if they are available for examination), stand with respect to the trait in question. For the present, we will be satisfied to see whether there appears to be any consistent transmission of the trait from one generation to the next, and whether it is transmitted from both maternal and paternal sides or only from one. After we have learned to recognize the more common patterns of heredity, we can examine these pedigrees to see whether the transmission of a particular trait is dominant or recessive, and whether it is autosomal or sex-linked. [Autosomes are all the chromosomes that are not sex chromosomes.] Remember, some of these traits may not be inherited at all. Our task is to try to decide which ones seem to be and which ones are probably not.

We will limit ourselves mainly to characteristics of form, feature, and coloring because these are the simplest to examine and classify. We are excluding some interesting traits, such as blood groups, color blindness, tongue rolling, and taste blindness for phenylthiocarbamide because we may use these in later studies. Other traits, such as nearsightedness (myopia), could be used in class but could not so suitably be used for the homework part of this investigation.

MATERIALS: (per group)

1 magnifying glass
1 protractor

PROCEDURE:

From the following list of human traits select 3, at least some of which you believe include differences between members of your own family. The class as a whole will work with all 9 traits and pool the results. Classify yourself and the members of your own team for the traits selected. Your teammates will take the other 6 between them. As homework, classify your parents, brothers, sisters, and other available relatives for each of the selected traits. Construct for each trait a pedigree chart.

In the pedigree chart, use a square for each male and a circle for each female person. Place all persons of the same generation on the same line, those of the next generation on the line below, etc. Connect married persons by a horizontal line, and connect the middle of this line to a horizontal line connected to each of their children, as in the model chart provided in Figure 1. Color solid all individuals who have a particular unusual trait, leave open those who are unaffected. If you are classifying a trait into three or more classes, use different kinds of shading or color to indicate the different types. Provide a key beside each pedigree to explain the meaning of the colors or shadings you use.

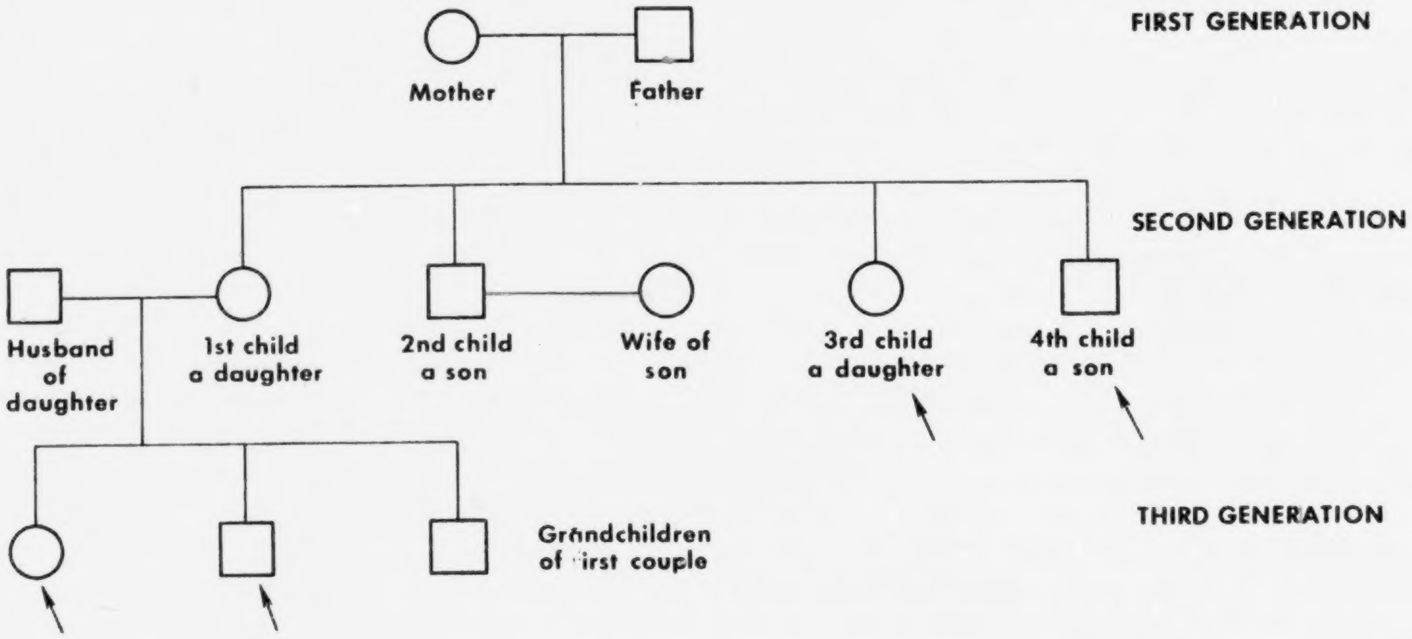

FIRST GENERATION
Mother
Father
SECOND GENERATION
Husband of daughter
1st child a daughter
2nd child a son
Wife of son
3rd child a daughter
4th child a son
THIRD GENERATION
Grandchildren of first couple

Figure 1. A sample pedigree. The arrows point to the symbols which might represent the student, male or female, in a family of two or of three investigated generations.

Description of Some Human Morphological Traits.

1. Median upper diastema. This is the presence of a quite conspicuous gap between the central upper teeth (middle incisors). See Figure 2. Usually a little piece of the gum extends down between the teeth when there is a diastema. Classify persons as having a diastema, or lacking a diastema (upper middle incisor teeth close together and touching each other). What percentage of the two types occur among the members of your class? (1)

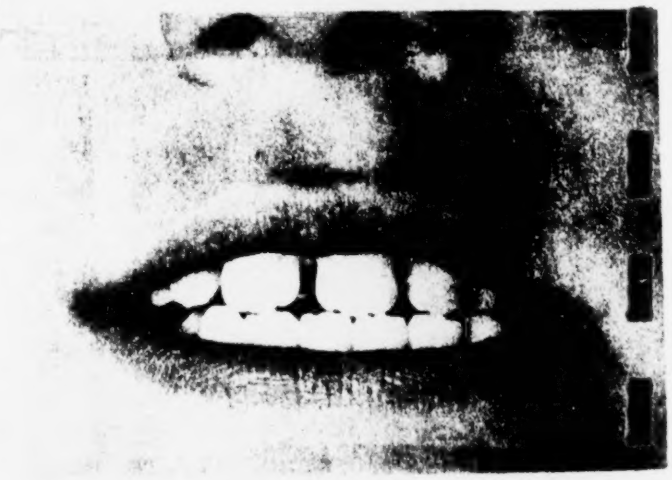


Figure 2. Median upper diastema.

Answer questions on Lab Report Sheet after class data has been pooled.

2. Attached or unattached ear lobes. Examine the lower lobed portion of the ear. This may hang down as a free lobe (unattached), or merge smoothly into the face (attached). Actually, it is better to classify persons into three classes, according to the types shown in Figure 3.

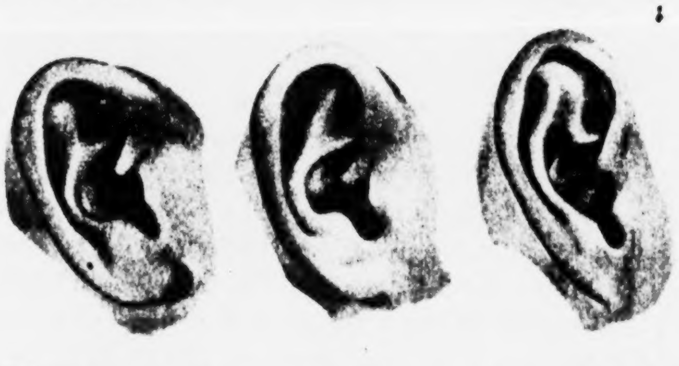


Figure 3. Free, intermediate, and attached ear lobes.

What are the percentages of the three types in your class? (2)

3. Mid-digital hair. Examine, with a lens, the middle segment of each of the 4 fingers of the right hand; then of the left hand. You will probably find hairs growing on some of these mid-segments of the fingers and not on others. Number the fingers, from the thumb side, 2, 3, 4, 5; and distinguish those of the left hand from the right hand by adding L or R to the numbers. Does the pattern on the right hand agree exactly with that on the left? (3) For example, if one uses a + sign for presence of mid-digital hair and a - sign for its absnece, if the pattern for 2L, 3L, 4L, 5L is -, +, +, +, is that also the pattern on fingers 2R, 3R, 4R, 5R? In older persons, or those who do a lot of such work as laundering or dishwashing, the hairs are often broken off or rubbed away. In such cases it is necessary to look very carefully to see whether there are any hair follicles on the mid-segments of the fingers. The follicles are the pits from which hairs grow out. If you can see even one follicle on a finger segment, classify it +. What are the commonest patterns in your class? (4)

4. Presence or absence of the long palmar muscle. The presence of this muscle is readily detected if one clenches the fingers tightly into a fist. If there is a long palmar muscle, its tendon then stands out prominently as a raised band passing centrally down the wrist. What percentage of the class lack this muscle? (5) Does this seem in any way to affect their ability to open and close the hand or to grip an object with it? (6)

5. Distal hyperextensibility of the thumb. Sometimes called "hitchhiker's thumb." Some persons can bend the terminal segment of the thumb back almost to a right angle with the basal segment (Figure 4). Others can bend it only slightly. With a protractor, measure the angle between the basal joint and the distal joint when the latter is extended as far back as possible. Use such landmarks in measuring as the axis of the basal joint, the division between the creases on the inside and those on the outside of the thumb at the joint, and the edge of the thumbnail. If the angle exceeds 45°, classify the person as +; if it is less, as -. What percentage of persons in your class have hyperextensible thumbs? (7)

6. Presence or absence of red hair. There are many grades of red hair, because the presence or absence of the reddish pigment in the hair does not affect the presence or absence of the darker black or brown pigments. Thus the reddest hair may be said to be on a blonde background; whereas "auburn" hair is red in the presence of some brown or black. The simplest classification of this trait is to disregard the other pigments, and simply to use two categories: "red" and "not-red". On this basis, what percentage of members of your class have red or reddish hair? (8)

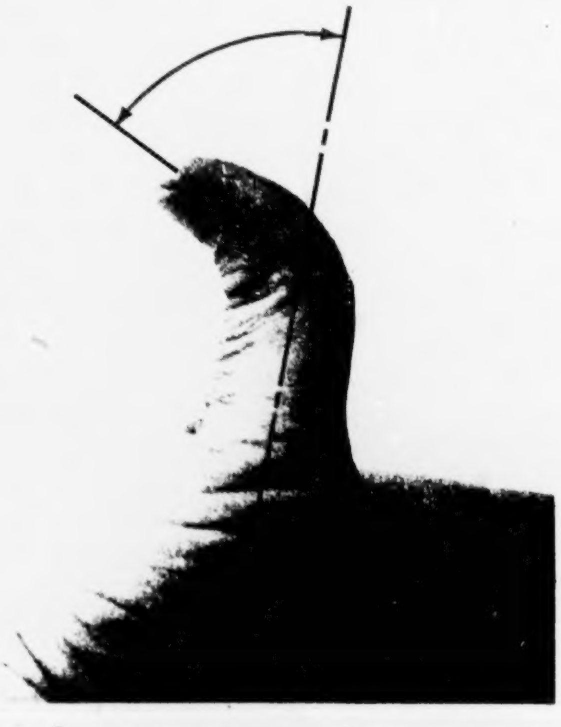


Figure 4. Distal hyperextensibility of the thumb, and the angle to be measured.

7. Eye color. This is a very complex and variable trait. Eye color differs markedly in different racial groups. In American Indian, Oriental, and African Negro peoples the color of the iris of the eyes is so deep and so uniform a brown

that it is almost black. Among Europeans of the more northern countries, there is a wide range of lighter colors, ranging from pure blue to moderate brown. The simplest classification is into just two categories: "blue" and "not-blue." In truly blue eyes, there is no pigment in the front layer of the iris at all, and the blue is owing to light scattering, like the blue of the sky. If you can see the least bit of pigment in the eyes of a person, when examining them under a very good light, classify them as "not-blue." A different two-class classification would be into "deep brown = black" and "mottled + blue." If you try to use this classification, use it as a completely separate classification from the one into "blue" and "not-blue." That is, you may wish to make two separate classifications for eye color on the same group of people, and see whether you can draw similar or different conclusions. What is the percentage of "blue-eyed" and of "not-blue-eyed" in your class? (9) What is the percentage of "deep brown or black-eyed"? (10)

8. Type of hair. There are almost as many grades of hair as there are of eye color. Be careful, too! We don't want artificial alterations of the hair to intrude into our classification, which should relate to the natural state of the hair. The suggested classification is into four grades of hair: kinky; curly; wavy; straight. Kinky hair is not only tightly curled but may further be described as self-bobbing, because it breaks off close to the scalp and makes a woolly pate. Curly and wavy are matters of degree and are difficult to separate. Class as wavy hair that which has only a slight wave, perhaps only in one area. Curliness would be all over the head, as well as more extreme. What proportion of the members of your class fall into each the four classes? (11)

9. Handedness. A person may be left-handed or right-handed. Often they are trained to write with the right hand even when naturally left-handed, so use several tests by answering the following questions. Which hand would you use to throw a baseball? With which hand can you grip harder? Which hand do you use to pick up a book or a pencil from the floor? Classify persons as left-handed if they seem to be ambidextrous, that is, if they use both hands equally well, for they probably have been trained to overcome a basic left-handedness. What percentage of students in your class are left-handed? (12)

In your notes summarize the results obtained by all members of the class in the classification of their fellow-members for the selected traits. After the homework is brought in, compare the pedigree charts for the same trait provided by different members of the class. For each trait, determine whether it appears to be transmitted in successive generations. Is it transmitted without a break from generation to generation? (13) Or does it seem now and then, or often, to skip a generation, by appearing in a grandparent and grandchild, but not in the parent? (14) Is it transmitted from the mother as well as the father? (15)

By analysis of the pedigrees, decide whether each trait is inherited in a simple Mendelian pattern or not. If so, determine whether it is dominant or recessive, and whether it is autosomal or sex-linked.

Alternative or Additional Traits. (Optional)

10. Widow's peak. Examine the hairline across the forehead. Is it straight, or is there a pointed downward projection in the center? The latter Figure 5 on the next page is called a widow's peak. What is the percentage of students with a widow's peak in your class? (16)

The following picture refers to statement 10 on previous page, Widow's peak.

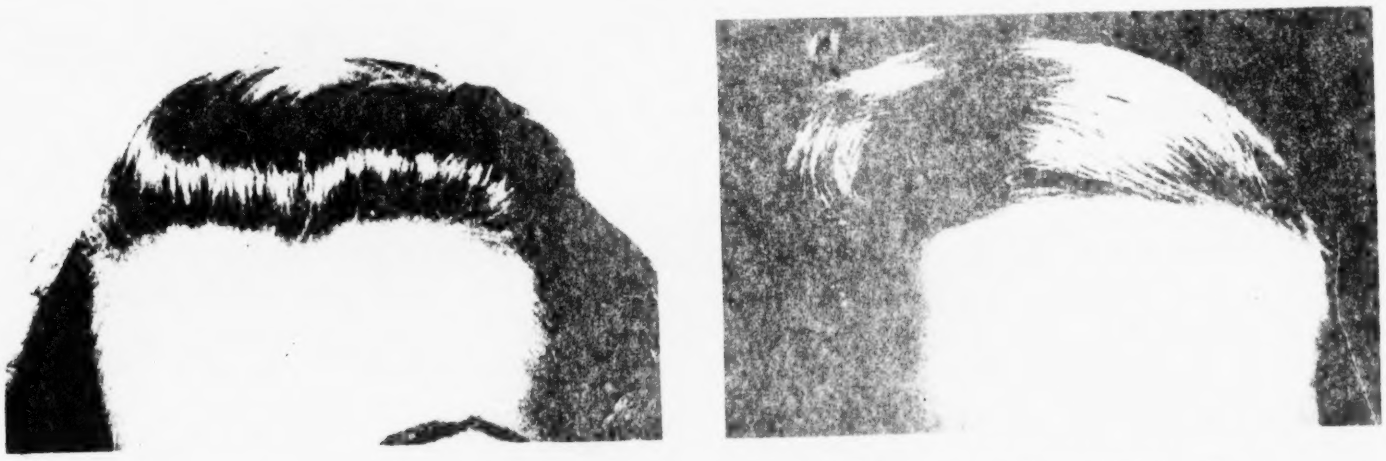


Figure 5. Widow's peak (left) compared with simple curved hairline (right). The widow's peak is characterized by a downward point of hair in the center of the forehead. (Courtesy of A. M. Winchester.)

11. Crooked little fingers. Some persons have little fingers the last segments of which bend sharply in toward the fourth fingers (Figure 6) How many such persons are there in your class? What is the percentage? (17)

12. Direction of the hair whorl. At the crown of the head there is a characteristic whorl in the hair. In some persons the whorl is clockwise, in others it is counterclockwise. It is usually easy to see in boys with a crew-cut, and of course it is harder to observe in girls. What proportion of the members of your class have a clockwise whorl? a counterclockwise whorl? (18)

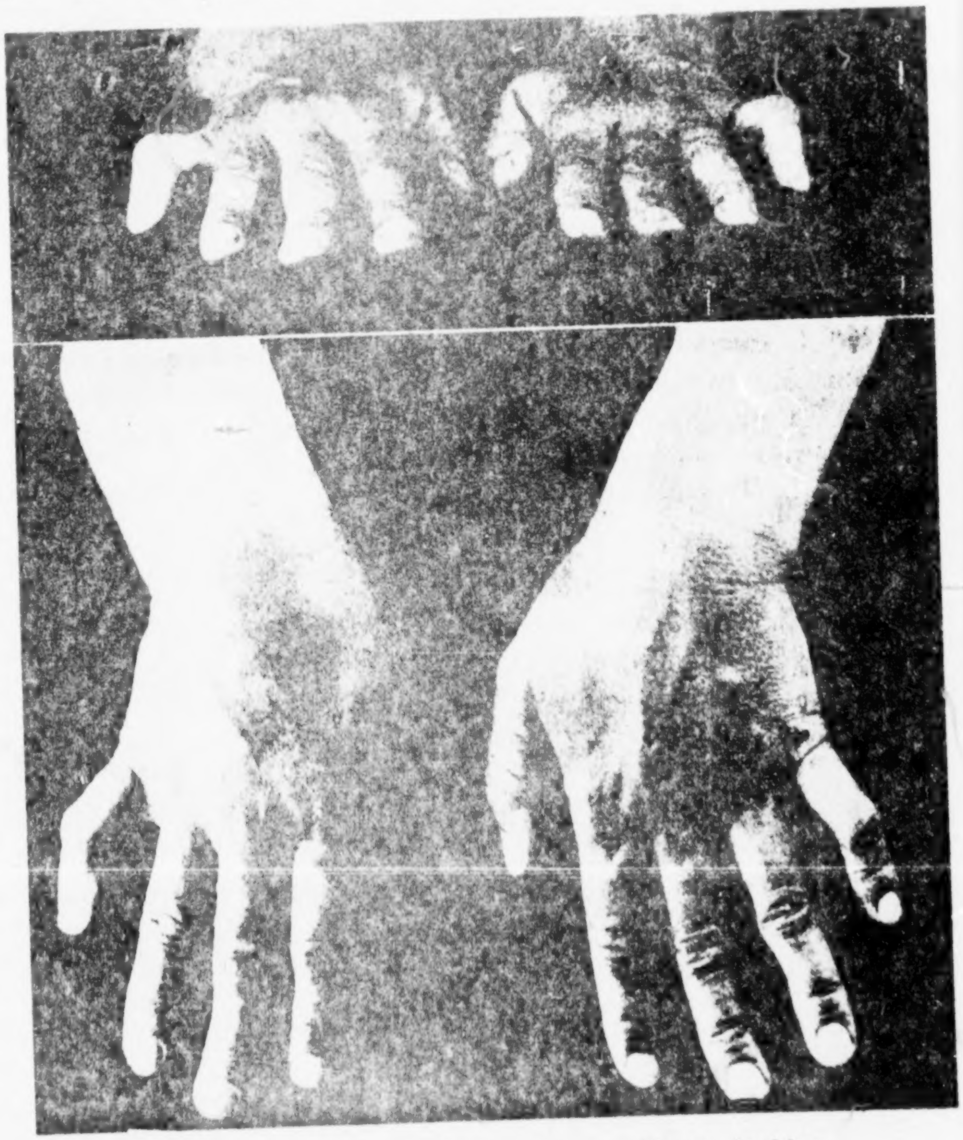


Figure 6. Crooked little fingers. Above, looking at hands horizontally. Below, same hands viewed from above. (Courtesy, *Journal of Heredity*.)

13. Absent teeth. The usual number of teeth on each side of the upper and lower jaw is as follows, starting from the middle: 2 incisors; 1 canine; 2 premolars; 3 molars. Check the number of teeth back to the first molar tooth on each side of each jaw. The most frequently missing teeth are incisors or premolars. Sometimes they are replaced with "peg" teeth; that is, the milk teeth in certain locations are never shed and are noticeably smaller than the others. Classify persons with missing teeth into four groups; missing upper incisor; missing upper premolar, missing lower incisor; missing lower premolar. Note also whether the missing tooth or teeth are right or left, and whether there is a peg tooth in its

place. What is the percentage of people with missing teeth in your class? (19) Do not count cases where a tooth has been extracted, of course!

14. Dimples. Everyone knows what a dimple is. Classify persons into four groups: dimple in right cheek; dimple in left cheek; dimple in chin; no dimple. What percentage of persons in your class have dimples? (20)

15. Freckles. You are aware, of course, that some persons have on their skin an accumulation of pigmentation in patches called freckles which can be seen on the face, hands and arms. These patches become more pronounced when the skin is exposed to sunlight. How many persons in your class have freckles? What is the percentage? (21)

Heredity

Name ______________________

Science IIA Hour _____

LAB REPORT SHEET

Date ______________________

Classification and Heredity of Human Traits

QUESTIONS:

1.

2.

3.

4.

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10.

11.

12.

13.

14.

15.

16.

17.

18.

19.

20.

21.

Family Pedigree

READINGS IN HEREDITY

References:

1. BSCS Blue Version, pages 327-354
2. BSCS Yellow Version, pages 507-587
3. Heredity, Bonner, 575.11 Bo
4. Genetics if Easy, Golstein, 575.11 Go
5. Principles of Genetics, Sinnott, Dunn and Dobzhansky, 575.1 Si 61
6. Genetics, Winchester
7. Heredity and Development, Moore, 575.11 Mo
8. Meaning of Evolution, Simpson, 575 Si 61
9. Understanding Heredity, Goldschmidt, 575.1 G623
10. Evolution, Genetics and Man, Dobzhansky, 575 D 63
11. The Mechanism of Evolution, Dowdeswell
12. The Repair of DNA, Scientific American, Feb. 1967, page 36
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SCIENTIFIC AMERICAN OFFPRINTS:

1. # 1 Genes of Molds and Men, Beadle
2. # 6 Genetic Basis of Evolution, Dobzhansky
3. # 17 The Gene, Horowitz
4. # 22 Darwin's Finches, Lack
5. # 25 The Mystery of Wheat, Mangelsdorf
6. # 26 The Mystery of Corn, Mangelsdorf
7. # 28 The Chemistry of Heredity, Mirsky
8. # 55 Ionizing Radiation and Evolution, Crow
9. # 60 The Duplication of Chromosomes, Taylor
10. #119 Messenger RNA, Hurwitz and Furth

STRUCTURE AND ORGANIZATION OF POPULATIONS

I. The Individual and Species Ideas

A. Definition

II. The Population and Community

A. Definition

Communities are organizations of living organisms, some stable and some in transition. Stable communities exist in equilibrium with their environment and any change in the environment may result in a change in the many populations within the environment. This is true because individuals and species compete with each other for water and nutrients (or food), light, and space, and the margin of superiority which one species enjoys over another may be very slight. The activities of man frequently disturb delicate natural equilibria, and the result is change in plant and animal populations or in the creation of blighted or polluted areas. Pollution can profoundly alter man's life, even making it ultimately impossible.

Living things and their environment influence each other, none lives without constantly influencing its surroundings.

Biological interactions involving man are the same sorts and subject to the same principles as those in non-human communities.

THE FUNCTIONING OF POPULATIONS

INTRODUCTION:

The populations of the hundreds of thousands of living species which inhabit the surface of the earth are limited. The limiting factors for any species are numerous and interrelated, but clearly a major one is the food supply. Animals will live, grow, and reproduce only if they can eat. If the food supply disappears, the animals will die.

Since the primary source of animal food is plant life, the total amount of life which can exist in the animal world is fixed by the rate at which photosynthesis takes place. The world wide rate at which photosynthesis takes place is in turn fixed by such factors as the amount of sunlight, seasonal variation in temperature, and the availability of water and nutrients necessary to plants, such as nitrogen, phosphorus, and sulfur.

Most photosynthesis takes place in the oceans and thus there is more life in the oceans than on land. On the surfaces of most seas we find countless microscopic plants called algae. Microscopic animals feed upon the algae and upon one another. In turn, larger animals feed upon the mixture of microscopic plants and animals. The total amount of animal life in the oceans, including all whales, fish, mollusk, protozoa and others is thus fixed by the rate at which the ocean plant life grows. A similar situation exists on the land areas of the earth.

Within the animal world there is increasing fluctuation. Populations of the individual species increase and decrease; new species appear and disappear. Whether or not a species of animal continues to exist depends upon many factors. Ultimatley, however, continued existence of a group depends upon the specific rate of production of young and upon the fraction of the young which survive through the breeding age. For a species of animal equally divided between males and females, the population will be stable if two young members enter the breeding period for every two who leave it. If the number entering drops appreciably, the population of the group as a whole will drop rapidly.

In a given group of animals, the fraction of young which survives to breed depends upon many factors in addition to the food supply and the birth rate. The offspring arising from species that watch over and care for their young until maturity is reached, stand a better chance of surviving to breed than do the offspring of other species. The existence of predators decreases the chances of survival. Frequently, within the species, there are threats to existence, involving cannibalism or competition for mates.

The mathematics of the interrelationships between living species is extremely complicated if more than two species are involved. Most living creatures live in complex environments and as a result the interrelationship between a given species and the living things about it are manifold.

Wherever an existence can in some manner be eked out, an organism can be found which manages to take advantage of the possibility. At any time, every possible niche of life is filled and the life within each niche is related to the other living groups about it. We see, in the oceans and on the land, vast systems of living things, in each of which the various species are dependent upon one another for their existence. A given system might include a diversity of plant life, bacteria, insects, fish, amphibians, reptiles, and mammals, all living in harmony. While such systems are frequently fairly stable and can exist for long periods of time, if any one of the component groups is disturbed appreciably, all of the other will be affected.

I Population Growth and Size Factors

A. Birth (Natality)

B. Death (Mortality)

C. Survival Curve

D. Migration (in and out)

E. Density defined:

The population density of any kind of organism in any given space at any given time is the result of the numerical relations among mortality, natality, immigration rate, and emigration rate. We may call these four rates the "determiners" of population density. In any study of population change, the biologist must consider these four rates and in any experimental study of populations, these determiners must be considered as variables.

It should be clear that any reference to the size of a population has meaning only in terms of space. If we are referring to changes in the size of a population within a given space, then we are referring to a density change, even if we have neither measured the space nor expressed the density numerically. The phrase "population density" is often abbreviated to "population".

The materials on page 222-223 may be found

TITLE The Challenge of Man's Future

AUTHOR Harrison Brown

PUBLISHER The Viking Press

PAGE NO. 5-7

A MONUMENT TO THE PASSENGER PIGEON

On May 11, 1947, in Wyalusing State Park, the Wisconsin Society for Ornithology dedicated a monument to the extinct passenger pigeon. A thoughtful conservationist wrote down his interpretations of this event.

> *We have erected a monument to commemorate the funeral of a species. It symbolizes our sorrow. We grieve because no living man will see again the onrushing phalanx of victorious birds, sweeping a path for spring across the March skies, chasing the defeated winter from all the woods and prairies of Wisconsin.*
>
> *Men still live who, in their youth, remember pigeons. Trees still live who, in their youth, were shaken by a living wind. But a decade hence only the oldest oaks will remember, and at long last only the hills will know ...*
>
> *For one species to mourn the death of another is a new thing under the sun. The Cro-Magnon who slew the last mammoth thought only of steaks. The sportsman who shot the last pigeon thought only of his prowess. The sailor who clubbed the last auk thought of nothing at all. But we, who have lost our pigeons, mourn the loss. Had the funeral been ours, the pigeons would hardly have mourned us. In this fact, rather than in Mr. DuPont's nylons or Mr. Vannevar Bush's bombs, lies objective evidence of our superiority over the beasts.*

-ALDO LEOPOLD, in *A Sand County Almanac* (New York: Oxford University Press, 1949), pp. 101, 108-110.

III. Population Interactions

A. Competition

Materials and Energy - It is important to recall that the energy flow through a biological community is a one way process and not a cycle. The energy flow becomes less and less available to organisms as it moves through the system. This requires a constant renewal of energy - and from only one significant source, the sun. In terms of population relationships, the size of producer populations (the capability of converting solar energy to forms usuable by other organisms), will determine the size of all consumer populations.

Food Chains

B. Predation

Undeniably the means of subsistence is the ultimate limit on any population, but in natural communities animals rarely live up to this limit. There usually seems to be plenty of food for all and death through starvation is probably rare.

Where a population does live up the limit of the means of subsistence, catastrophe is likely to result. The incredible hordes of migratory locust, which at times strip the countryside of every green thing in various parts of the world, are a case in point. Locust plagues have been recorded in Egypt and Assyria since the beginning of written history. Disastrous insect outbreaks are often the consequence of man's interference with the ordinary balance of natural communities, but this can hardly be the case with locusts.

Research indicates that there may be two forms of locusts - migratory forms, or those raised under crowded conditions and solitary forms or those raised in isolation. The solitary forms live dispersed in grasslands slowly building up in abundance until, at some stage in crowding, the restless, gregarious migratory form appears and the great hordes of insects, darkening the sky, take off to devastate any vegetation in their paths. The swarms may fly out to sea and they almost always end in some environment where the species cannot survive. New swarms are then built up from individuals that stayed behind in the homeland. The mass suicide clearly serves as a final limit to population growth.

The mass suicide of these insects brings to mind the famous case of the Norwegian lemmings. Lemmings are small, mouselike rodents that inhabit the subarctic regions of both hemispheres. Most species show rather regular cycles of abundance with peaks at intervals of three or four years. The Norwegian lemmings have attracted particular attention because in years of abundance they pour down from the mountains toward the sea through farms, villages and towns - indifferent to all obstacles.

There have been many laboratory studies of the effect of crowding on animals. Overcrowding results in a slowed rate of growth and in undersized, weak adults - easily enough explained in terms of food shortage. But even when provision is made so that an abundance of food is always available, there may be striking changes in behavior and physiology. Most of the studies have been made with rodents and in these animals, the overstimulation under crowded conditions results in a disruption of the usual endocrine balance, causing most notably, an enlargement of the adrenal cortex. The consequences are diminished reproductive functioning in both males and females, inhibition of growth, increased susceptibility to disease, and so forth. The endocrine changes under caged conditions are clear; whether comparable changes occur under crowded condition in the wild is not well established, although it would seem a likely explanation of abnormal behavior. Observations made under experimental conditions must always be checked with studies in the field if they are to be correctly interpreted.

Probably the best known studies of the behavior of mammal populations under confinement are those carried out by John Calhoun with the Norway rat. In general, Calhoun and others have found that under crowded conditions, but with ample food available, behavioral changes occur that greatly reduce reproduction. The most striking cases involve the formation of what Calhoun has called "behavioral sinks". In experiments in which a large enclosure is subdivided into pens with restricted access, dominant males may establish more or less normal reproductive relations in some pens, while the other pens will be occupied by the outcasts, who show various abnormal behavioral patterns - who show "social pathology".

Females in a behavioral sink become shoppy nest builders or fail to make nests at all; litters are aborted or young neglected, making for a high infant mortaility. Some males become extremely phlegmatic, losing all interest in sex or in fighting. Others become hypercetive - the "probers" - attempting to mate with other males or with females not in estrus. They also tend to be cannibalistic, eating the abandoned young.

Thus the "vice and misery" of the Malthusian proportions develop in rat populations as well as in humans. Invariably one compares rats in a behavioral sink with humans in a crowded ghetto. Certainly people often behave very much like rats, although certainly the differences outweigh the simalarities.

IV. Periodism

A. Of Populations and Communities

B. Geological Factors

Populations and communities, wherever they may be, are dynamic groups living in (and forming part of) environments that are also dynamic; they change constantly, from hour to hour, season to season, year to year, and epoch to epoch. The rhythm of day and night is reflected in the activities of all communities. Here in the Temperate Zone we are all familiar with the dramatic cycle of the seasons: the fall of leaves, migrations of birds, disappearance of insects, and the seemingly closing down of nature's business in the fall, the quietness of winter, the rebirth of spring, and the bustling activity of summer. The cycle appears to annually repeat itself but never exactly. One rare day in July may be much like another a year hence, but as the years pass they bring slower changes. The student who traces the larger history of the earth finds great changes in matters of the appearance, rise, fall, and disappearance of specific populations and communities.

POPULATION GENETICS

INTRODUCTION:

The gene as the ultimate source of biological characteristics and the sea of organic change, or mutation, was recognized soon after 1900 when the genetic principles of Mendel were rediscovered, but not until population genetics emerged as a special development did the full impact of this new discipline modify profoundly the basic preoccupation of students of evolution. For population genetics took as one of its principle tasks the analysis of microevolution by studying the genetic dynamics of populations. And since the cutting edge of evolution is at that level, the insights provided by this new approach have both enriched evolutionary concepts and focused attention on its functioning mechanisms.

I. Genetic Equilibrium

A. Gene Pools

B. Hardy-Weinberg Law

II. Evolution or Changes in Genetic Equilibrium

EVOLUTION - Our new knowledge of gene structure promises to fill an important gap in our understanding of evolution. We can now define life in objective terms - ability to replicate in the manner of DNA, and to evolve through mutation and natural selection. Biochemists may, before long, be able to duplicate in test tubes the conditions under which "living" molecules arose on earth a few thousand million years ago. Understanding of the nature of life is thus replacing mystery.

We now see evolution as a continuous process by which elements evolved from hydrogen, inorganic molecules, and "organic" molecules arose; these interacted to produce replicating systems like DNA; virus-like systems evolved into cellular forms; these in turn evolved into multicellular plants and animals; and finally man arose, with his capacity for adding cumulative cultural inheritance to the mechanical biological inheritance of his remote ancestors. All this is now believed to be an orderly process in which the individual steps are not unlike those we observe today in experimental organisms. Separate mutational steps occur inevitably and those that confer selective advantages to the individuals that carry them are multiplied preferentially. Organic evolution, though unpredictable in direction, is bound to occur when the conditions are favorable.

A. Mutation

B. Natural Selection

C. Natural Selection in Human Populations

EVOLUTION BY NATURAL SELECTION OF HERITABLE VARIATIONS

An example of the relationships between natural selection and mutation is a condition known as sickle-cell red blood cells that occurs among West African indigenes. The gene causes formation of abnormal hemoglobin, the molecules of which attach themselves to one another end to end, thereby distorting the cells and causing them to look like sickles. These cells are easily destroyed, and in homozygotes (individuals that inherited only the sickle-cell gene) under conditions of oxygen deficiency, this results in anemia, thrombosis, and death. It is not surprising that the gene is recessive. On the other hand, this abnormal hemoglobin prevents the entry in the red cells of the parasite *Plasmodium falciparum*, which is responsible for a type of malaria. In regions where malaria is endemic, an equilibrium is set up between the number of normal homozygous individuals liable to die of malaria to the number of individuals homozygous for the sickle gene that are liable to die of thrombosis. The heterozygous individuals (who have both normal and sickle cell genes) get the best of both worlds, for they are protected from both dangers. But their genetic constitution makes inevitable the production of homozygote offspring of both kinds, who will pay their different kinds of penalty.

In West Africa, the sickle gene is present in 20 percent of the population. With this percentage, four out of five homozygous sickle children die. The descendants of these populations in the U.S. where there is no endemic malaria, show only 9 percent with sickle genes. This example shows how natural selection, opportunistically, can convert a lethal gene into one that confers survival value under certain ecological conditions. Furthermore, it provides a case of the special advantage enjoyed by heterozygotes, and shows how the percentage of a gene in a population can become changed. The latter is of particular importance because, as a result, evolution can also be defined as a statistical change in a gene pool of a population.

HUMAN POPULATIONS

Required Reading:	The Human Population, Deevey, S. A., Sept. 1960 Scientific American Reprint #608
	"How Much Space Does a Man Need?" Lagemann, J. K. Reader's Digest August 1969 reprints available in Resource Center

I. Basic Ecology of Man

A. Primitive Man and Environment

B. Cultural Modification of Human Ecology

C. Environmental Modification

II. Demography, Past and Present

A. Definition

B. Growth of Human Population

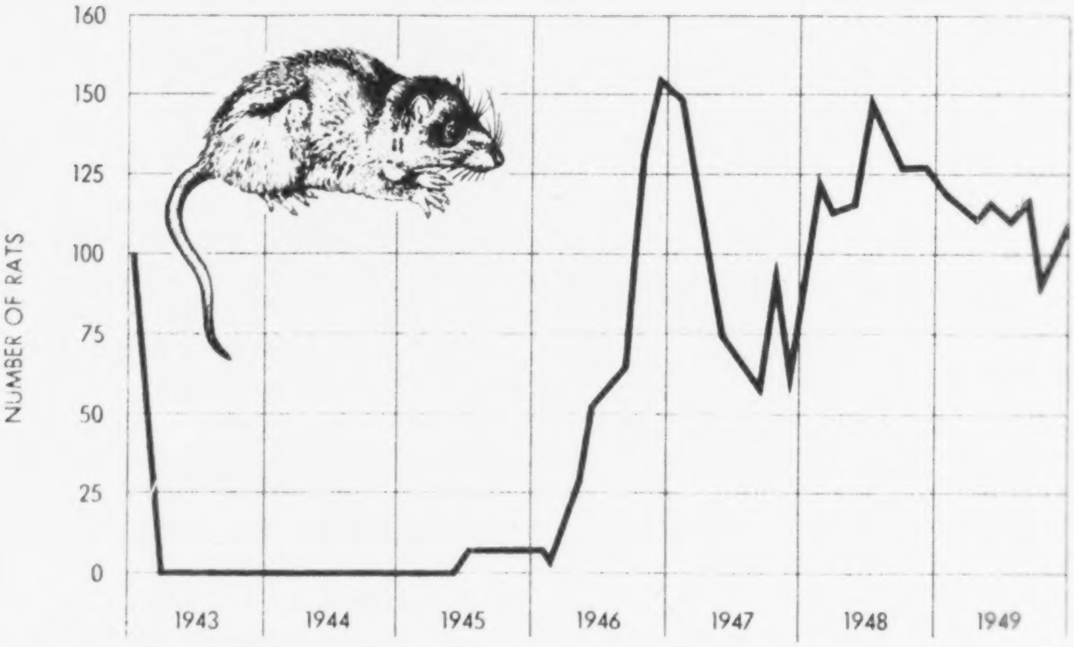
C. How many men can the Earth support?

THE IMMEDIATE PROBLEM AND SPECTRE OF TROUBLE

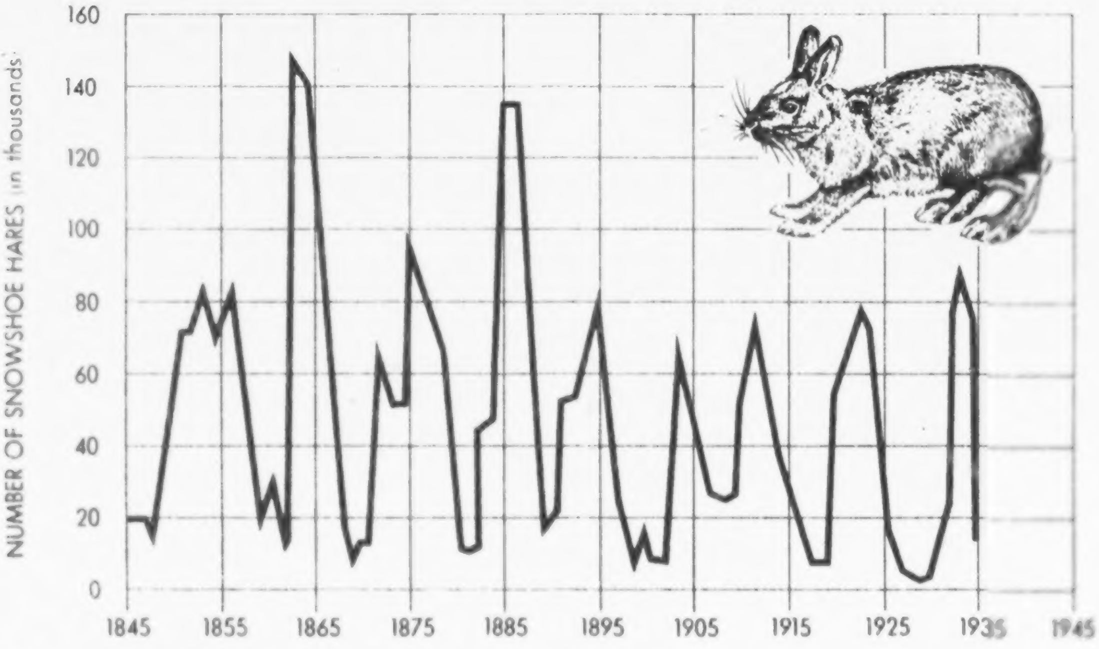
The tensions which exist in the world today are greater than at any previous period of history. At one end of the scale there is the well-fed, well-clothed, and well-housed minority, which guards jealously its present accumulation of wealth--parts of which, however, are already beginning to decay In the middle of the scale is another minority, which, as the result of prodigious efforts, has undergone partial industrialization. The people of such regions are still poor, some are enormously overcrowded, and all are prepared to take practically any step, no matter how violent it may be, which might enable them to complete the transition.

By contrast with the people of the wealthy minority, the people of the transition areas have relatively little to lose and much to gain by violent action. And at the bottom of the scale of wealth is the over-whelming majority of disease-ridden, hungry, under-privileged persons who have been exploited by the privileged minority and who cast envious eyes upon the wealth of Western nations. The people who belong to the underprivileged majority are restless, and in many regions of the world they are in active revolt. Industrialization is beginning to spread to such areas with consequences which can at present be only dimly perceived.

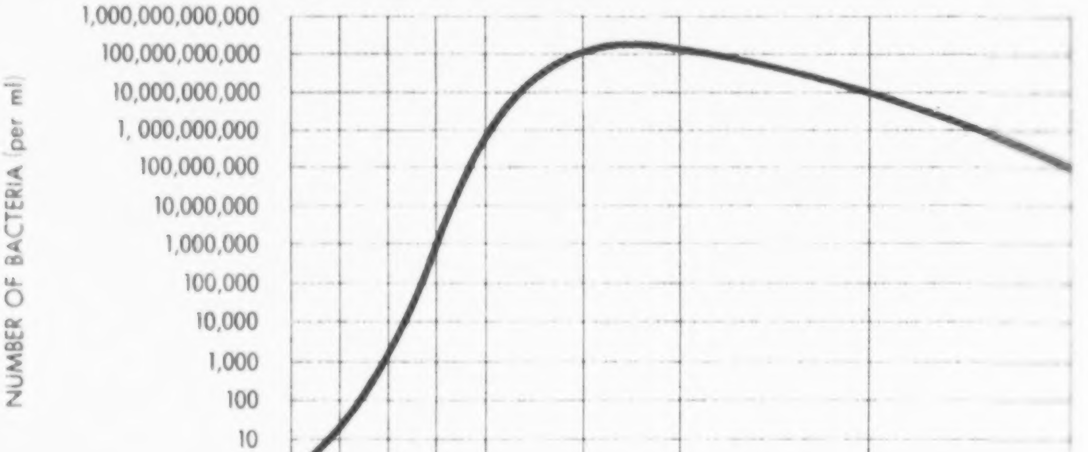
It is clear that the future course of history will be determined by the rates at which people breed and die, by the rapidity with which non-renewable resources are consumed, by the extent and speed with which agriculture production can be improved, by the rate at which underdeveloped areas can industrialize, by the rapidity with which we are able to develop new resources, as well as by the extent to which we succeed in avoiding future wars. All of these factors are interlocked.



1-15. Graph of brown rats in a city block, Baltimore, Maryland.



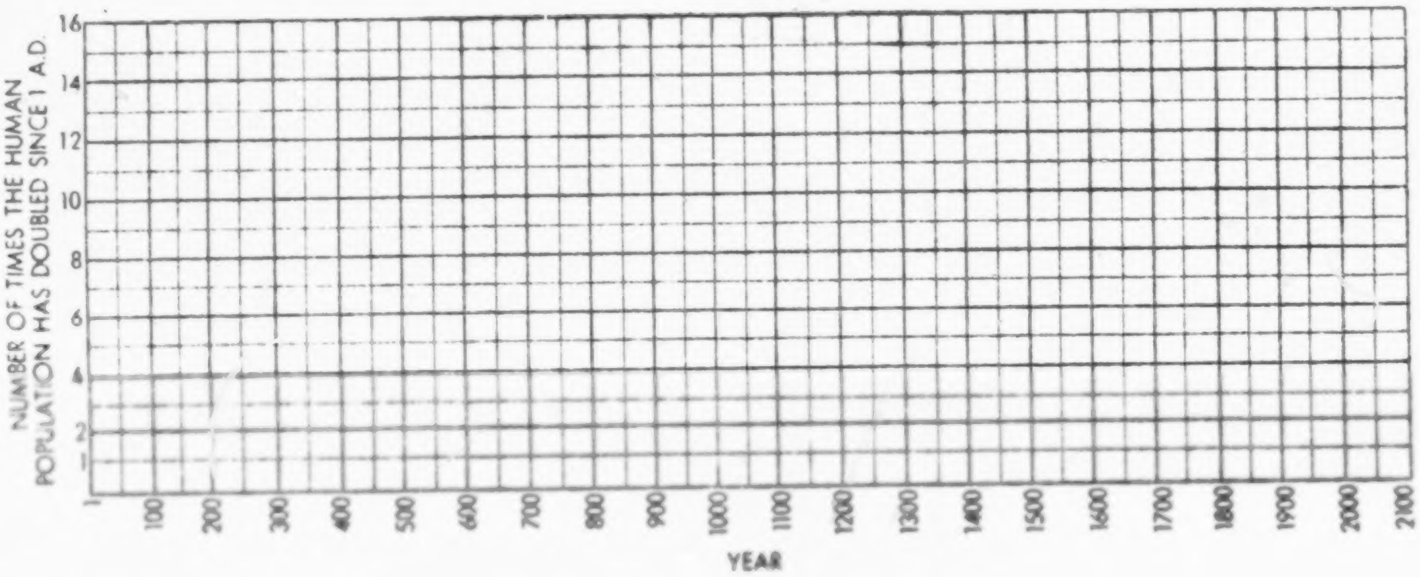
1-16. Graph of a snowshoe hare population in Canada.

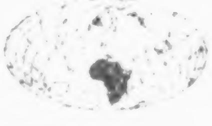
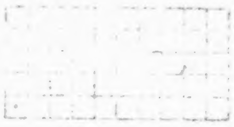
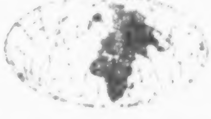
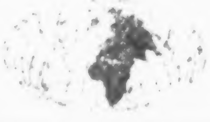
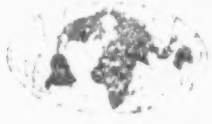
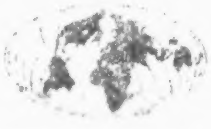
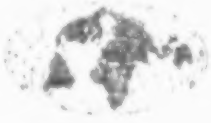
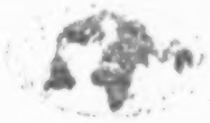
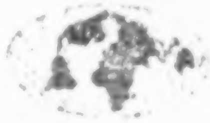
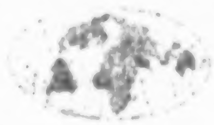
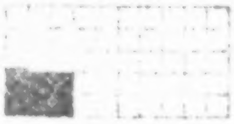
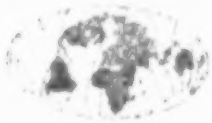
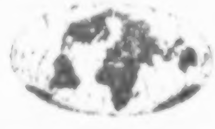
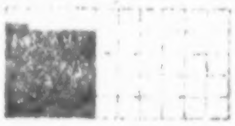
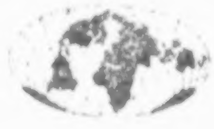


1-17. Graph of a bacterial population.

If you use the estimated figure of 12,000,000 people on the earth in the year 1 A.D., it is possible to see the number of times this population has doubled in any period of time. The human population had doubled by 1650. It had doubled over nine times by 1950. Here are some other figures:

Year (A.D.)	Number of times the population has doubled since 1 A.D.
1	1
1650	2
1750	3
1850	4.5
1950	9.2



YEARS AGO	CULTURAL STAGE	AREA POPULATED	ASSUMED DENSITY PER SQUARE KILOMETER	TOTAL POPULATION (MILLIONS)
1,000,000	LOWER PALEOLITHIC		 .00425	.125
300,000	MIDDLE PALEOLITHIC		.012	1
25,000	UPPER PALEOLITHIC		.04	3.34
10,000	MESOLITHIC		.04	5.32
6,000	VILLAGE FARMING AND EARLY URBAN		1.0 .04	86.5
2,000	VILLAGE FARMING AND URBAN		1.0	133
310	FARMING AND INDUSTRIAL		3.7	545
210	FARMING AND INDUSTRIAL		4.9	728
160	FARMING AND INDUSTRIAL		 6.2	906
60	FARMING AND INDUSTRIAL		11.0	1,610
10	FARMING AND INDUSTRIAL		 16.4	2,400
A.D 2000	FARMING AND INDUSTRIAL		46.0	6,270

New York Herald Tribune

FAO: BIRTHS CANCEL FOOD OUTPUT GAINS

By Darius S. Jhabvala
Of The Herald Tribune Staff

UNITED NATIONS.

World food output made impressive gains during the past decade, but production increases in the main were wiped out by rapid population growth, the UN Food and Agricultural Organization said in a report published yesterday.

The report warned that world population is expected to grow at an even faster rate and prospects for any lasting improvement in agriculture "do not appear very bright."

It said a four-fold increase in production will be needed in the developing countries during the rest of this century just to keep pace with present standards.

The report was distributed three days after Pope Paul VI exhorted the General Assembly to strive "to multiply bread so that it suffices for the people of mankind and not rather favor artificial control of birth, which would be irrational."

FAO Director-General B. R. Sen said in the report that "technical means . . . are available" to provide more food.

But, he warned the task cannot be accomplished "unless the leaders of nations are alive to the issues at stake and are prepared to devote a large share of the world's resources to meet the looming crisis."

He said the remaining years in this century "will be the most critical in human history." UN experts expect the world population of 3.3 billion almost to double by the end of the century.

Mr. Sen cautioned that "the third post-war decade is one when the Malthusian correctives (war, pestilence, famine) will inexorably come into play unless organized will and dedicated endeavor, which we have been trying to build through various efforts, can find effective expression."

The report notes that the food-population situation has not only brought great urgency to the task of expanding production of food, "but has also begun to cause widespread rethinking of the attitude to population control."

Friday, October 8, 1965

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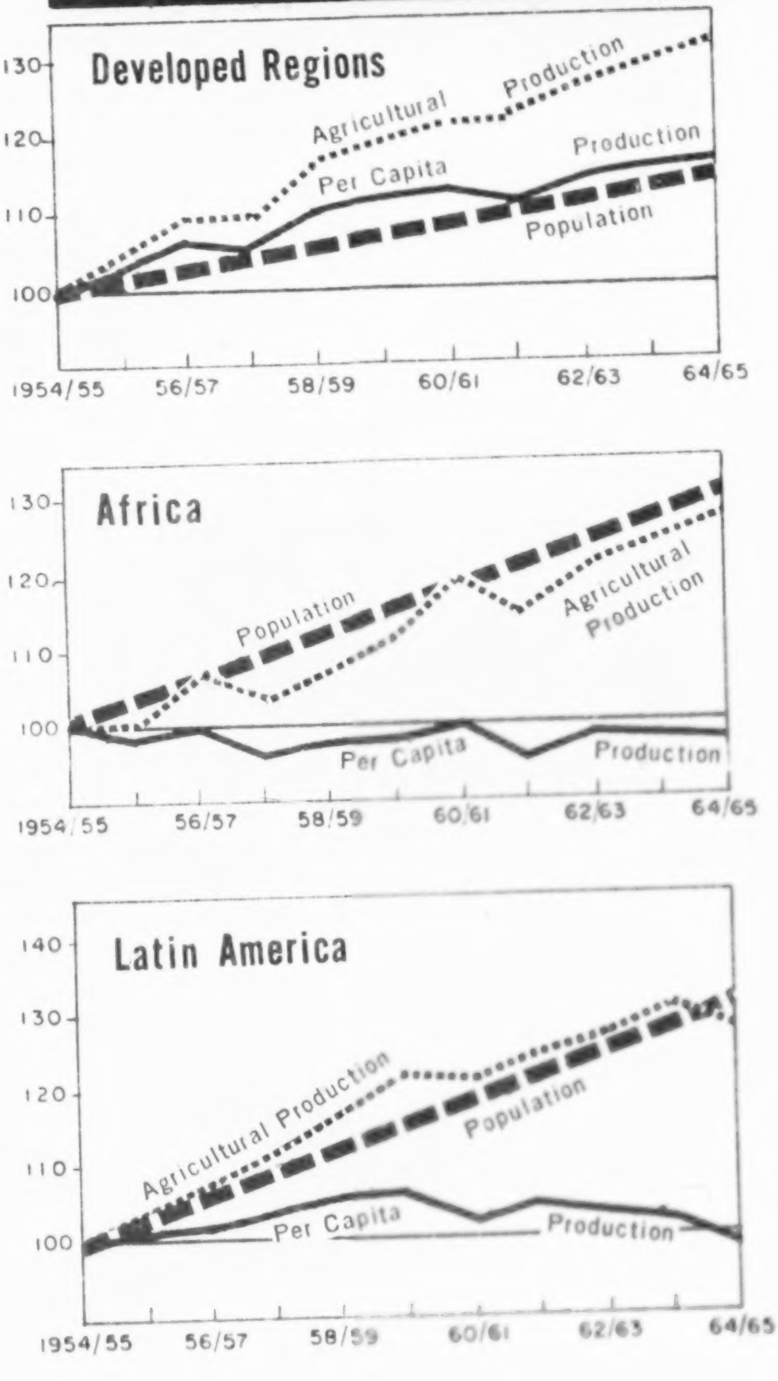
Agricultural Production and Population Growth



Laboratory Problem

POPULATION GROWTH: A MODEL

INTRODUCTION:

Just as we need tools like the microscope to help us extend our powers of observation, so we need mental "tools" to help us extend our thinking. One such mental tool is called a model. Here the word is used in a sense that is somewhat different from the sense in which it is generally used. The model we are discussing is not an object; it is a mental image. This kind of model simplifies a complex, real situation so that we can more easily understand it. Should the model give results similar to those given in the real situation, we can have confidence that it "works" in the same way the real situation does. Of course, the two will never match exactly, but the degree of matching will determine the extent of our confidence.

Because the model is a simplication, it differs in some respects from the real situation. The simplifications we make are called assumptions. To simplify, we assume certain things that may be only approximately true. We must keep these assumptions in mind whenever we use the model to try to understand a real situation.

PURPOSE:

The purpose of this exercise is to observe the way in which a model population might grow. In the next exercise we will set up an experiment to see how closely a real population fits our model.

MATERIAL:

ordinary graph paper, 1 sheet per student
semilogarithmic graph paper, 1 sheet per student

PROCEDURE:

A. Setting up the Model

We can build our model, our mental tool, around a real organism - the house sparrow. We will begin on an island, in the spring of 1967, with a population of 10 house sparrows - 5 pairs, that is, 5 males and 5 females.

Assumption 1:	Each year each pair of sparrows produces 10 offspring, always 5 males and 5 females.
Assumption 2:	Each year all the breeding (parent) birds die before the next spring.
Assumption 3:	Each year all offspring live through the next breeding season. (In most real situations, some parents would live and some offspring would die. But taken together, Assumption 2 and 3 tend to balance each other, thus reducing the difference between our model and a real situation.)

Assumption 4: During the time of our study, no other sparrows arrive on the island, and none leave.

B. Growth of the Model Population

Now we want to see how this model population (we can all it a hypothetical population) will grow. To do this, we must calculate the size of the population at the beginning of each breeding season (each spring). According to Assumption 1, in 1967, we have 5 pairs, each producing 10 offspring, a total of 50 offspring. According to Assumption 2, the 10 breeding birds of 1967 will die before the next spring. According to Assumption 3, all of the 50 offspring live to the spring of 1968. Thus, at the start of the 1968 breeding season, there will be 50 house sparrows on the island. According to Assumption 1, 25 of these will be males and 25 will be females - 25 pairs, each of which will produce 10 offspring. Go on with this kind of reasoning to calculate what the island's sparrow population will be at the beginning of the breeding season in 1969, 1970, 1971, 1972, and 1973.

We now have a series of numbers, but they probably do not give us any clear idea of the way the population grows. A graph will show us more. Construct the graph so that the years are shown along the horizontal axis (abscissa) and the number of birds, along the vertical axis (ordinate). You will need to make the vertical scale large enough to show the small 1967 population. Plot as many of the generations as you can . (Label line A on the Graph).

The difficulty we meet in plotting our data on population growth - the choice of a scale large enough to show small gains but not so large that later generation will go beyond the height of the ordinate - can be overcome with another tool. This tool is semilogarithmic (usually called "semi-log") graph paper. It is not necessary to fully understand the mathematics of logarithms to appreciate our present use of this tool. Your teacher will explain what you need to know to be able to plot the data.

Now construct your semi-log graph with the same data you used before. (1) What advantage(s) does the semi-log graph have over the ordinary graph for plotting data on population growth?

Place the two graphs in front of you. (2) How does the slope of the line connecting the plotted points change as you go from left to right (from year to year) across the ordinary graph? (3) What does this mean in terms of rate of population growth? (4) What kind of line shows the same thing on the semi-log graph?

Finally, we must relate our results to the purpose of the exercise. (5) In one or two sentences, describe the growth of a hypothetical population that is limited by the assumptions stated in this exercise?

FOR FURTHER INVESTIGATION

We can examine the effect that changes in our assumptions will have on population growth. By doing this we can expect to gain a better understanding of the factors involved in population changes. (Reference: BSCS Green Version). (Use ordinary graph paper).

1. Change Assumption 2 as follows: Each year two-fifths of the breeding birds (equally males and females) live to breed again a second year and then die. All other assumptions remain unchanged. Calculate the population size of each generation. Compare these results with the results of the original assumptions by drawing a graph on the grid used for the original data. (Line B on original graph.)
2. Change Assumption 3 as follows: Each year two-fifths of the offspring (equally males and females) die before the next breeding season. All othe assumptions remain unchanged. As before, calculate the populations and draw a comparative graph. (Line 3 on original graph).
3. Change Assumption 4 as follows: Each year 50 new house sparrows (equally males and females) arrive on the island from elsewhere. None leave. All other assumptions remain unchanged. Calculate the populations and draw a comparative graph. (Line D on Original Graph.)

Laboratory Investigation

STUDY OF A YEAST POPULATION

INTRODUCTION:

In the study of a hypothetical population, the data on the numbers of house sparrows were derived from the assumptions built into the model. Now we shall obtain data from a real population. Gathering data on the growth of a real population of house sparrows would require years of counting and observing. Since we do not have time for such census-taking, we must turn to an organisms that reproduces rapidly. Yeast organisms are suitable for this study.

PURPOSE:

The purpose of this experiment is to study the pattern of growth in a real population under controlled laboratory conditions. We can set up the following statement as our hypothesis: In a real population the pattern of growth is the same as that of the sparrow population model studied.

BACKGROUND INFORMATION:

Yeast organisms are used not only because they reproduce at a rate that will allow us to complete our investigation in about ten days but they are conveniently small - several million can be kept in a test tube. Dry yeast grains are composed of many inactive plants. These tiny plants become active and reproduce in a suitable medium, a mixture of materials that will support their growth. A population of organisms in a medium is called a culture. Figure 1 shows yeast organims in the medium, as they would appear under a microscope.

MATERIALS AND EQUIPMENT:

A. For Preparation of Medium

2000 ml. Erlenmeyer flask
graduated cylinder
large stirring rod
source of heat
pressure cooker
test tubes of about 20 ml capacity, 1/student plus 1/team of 10 students
square of aluminum foil. large enough to form a cap over a test tube, 1/student
balance
spatula
clean, soft cloth
yeast extract, 2.5 grams
monobasic potassium phosphate, 2 g
glucose, 40 g
peptone, 5 g
distilled water, 1000 ml.

B. For Preparation of Cultures

test tubes, same size as above, containing 10 ml. of medium, 1 per student
glass marking crayons, 1 per team of 10 students
dry, active yeast, 1 package
fine pointed forceps
square of aluminum foil to make yeast packet, 1 per team

C. For Counting Day

test tubes, as as above, containing yeast cultures, 10 per team
microscopes, 1/pair of students
microscope slides, 2/student
cover slips (all same size), 2 per student
medicine droppers or 1 ml. pipettes, 1 per student
test tubes containing 10 ml. of medium, for determining the number of cells at "zero" hours of growth, one per team
test tubes containing 9 ml. of water, about 15 per team

D. For Examining the Results

ordinary graph paper, 1 sheet per student

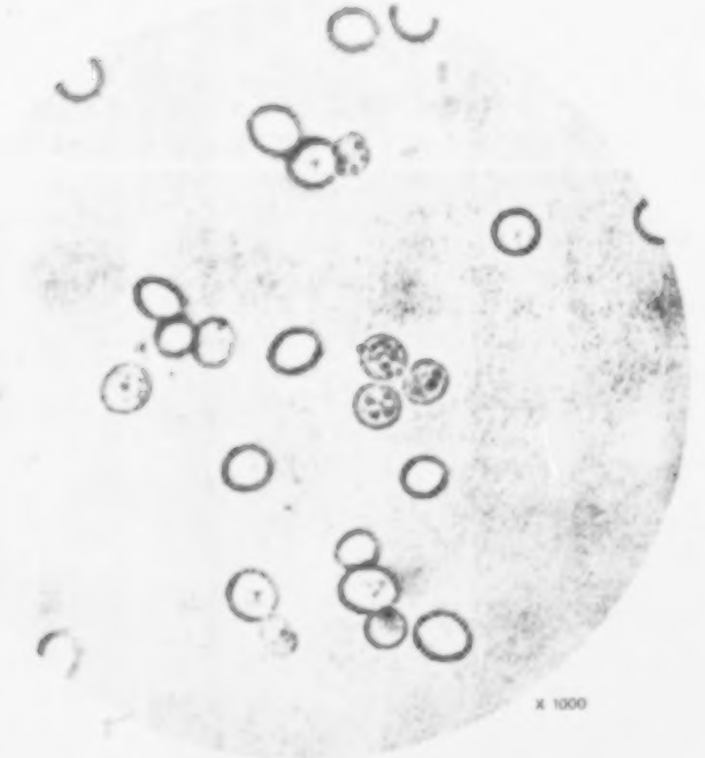


Figure 1.: Yeast organisms in a microscopic field. The magnification in this photograph is greater than that obtained with the usual high power objective. How does an increase in the magnification affect the size of the field?

PROCEDURE:

A. Preparation of Medium (to be done for the whole class by a small team of students)

You need 10 ml. of medium for each student, plus 10 ml. additional for each team. (The quantities listed above will make a little more than 1000 ml. of medium.) Compute the needed amount of each material. Weigh out the amounts of dry materials, and add them to the required volume of water. Dissolve the materials by stirring continually over a low heat source.

When properly prepared, the medium is sparkling clear and slightly yellow in color. If it is cloudy, you have done something wrong. Check your **calculations.**

Pour 10 ml. of the medium into each tube (one per student plus one per team). Shape a square of aluminum foil as a cap over the mouth of each test tube. Sterilize in an autoclave or pressure cooker, at 15 pounds pressure, for fifteen minutes. Store the sterile test tubes of yeast medium as directed by your teacher.

B. Growing the Population

Each team of 10 students should have a set of 10 test tubes of yeast medium. Using a glass marking crayon, mark each tube with a team symbol. Number the tubes from 1 to 10, and assign a number to each team member.

From a package of dry, active yeast, choose 15 to 20 grains of yeast - all **the same size.** Put a grain of yeast in Tube 10. Be sure the grain is in **the medium.** Mix by holding the tube firmly between the fingers and thumb of one hand and striking the bottom of the tube forcefully with the fingers of the other hand. Place the tube in a warm, dark place as directed by your teacher; in other words, incubate it. Put the remaining grains of yeast in an aluminum-foil packet, and label with the team symbol. Store as directed by your teacher.

On each succeeding day, take out the tube of medium with the next lower number (Tube 9, 8, 7, etc.). Add a yeast grain from the storage packet, mix, and incubate as before. Make daily observations of any change in the yeast cultures. Record the observations in your data book.

C. Counting the Population

When the last culture in the series (tube 1) has been incubated for twenty-four hours, a count of yeast organisms in all 10 tubes must be made. All counts must be taken at the same time. The members of each team will work in pairs - students 1 and 2 together, 3 and 4 together, etc. Each student will need to make a count from his own tube and a count from the tube of his partner. Thus there will be two counts on each of the 10 tubes. You will need to prepare two forms, each one like the form shown.

Team __________ Culture No. __________ Dilution Factor ______

Member of Pair	Fields					Total	Average	Average X Dilution Factor
	1	2	3	4	5			
A								
B								

Pair Average _________

Use one form for recording the counts made from your culture by you (A) and by your partner (B). Use the other form for recording the counts made from your partner's culture by you (A) and by your partner (B).

First, shake your own test tube until the yeast organisms are evenly distributed. Using a pipette, immediately place 0.1 ml. of the culture on a clean slide (or, using a medicine dropper, place 2 drops on the slide.) Place a clean cover slip over the culture on the slide. Do not press down on the cover slip. Position the slide on your microscope stage, and focus under low power; then switch to high power. Do not tilt the stage!

Count the number of individual organisms in 5 different high power fields, all on your slide, as indicated in Figure 2. CAUTION: Yeast organisms are difficult to see if the light is too bright. Yeast organsims often stick together. Each individual organism in any clump is to be counted separately. Buds also count as individuals. Record the 5 counts on your data form (first form, line A).

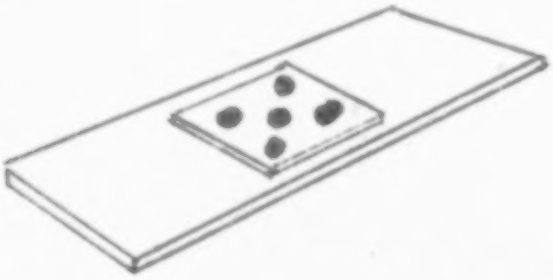


Figure 2

If the fields are too crowded for easy counting, you must make a dilution of the culture. To do this, obtain a test tube containing 9 ml. of water and label this dilution D1. Then shake the yeast culture until the organsims are evenly distributed. Using a clean pipette, transfer 1 ml.

(or, if you use a medicine dropper, 20 drops) of the culture into the dilution tube. Rinse the pipette (or the medicine dropper) several times by running clean water in and out of it. Mix the contents of the dilution tube thoroughly. Now transfer 0.1 ml. (with a pipette) or 2 drops (with a medicine dropper) from the dilution tube to a slide, and proceed to count the cells as directed above. If the microscopic field is still too crowded for easy counting, transfer 1 ml. of the contents of Tube D1 to another test tube containing 9 ml. of water. Mark this dilution D2. It may even be necessary to use a third dilution. See Figure 3 (series of dilution tubes). In Tube D1 the culture will be diluted 10 times; in Tube D2, 100 times; in Tube D3, 1000 times. If you make dilutions during counting, record the proper number 10 or 100 or 1000) after "dilution factor" on the data form. If you make no dilutions, the dilution factor is 1. Now make a slide from your partner's culture. Make 5 counts as before, and record them in your data form (second form, Line A). Copy your partner's data (his lines A) onto your lines B.

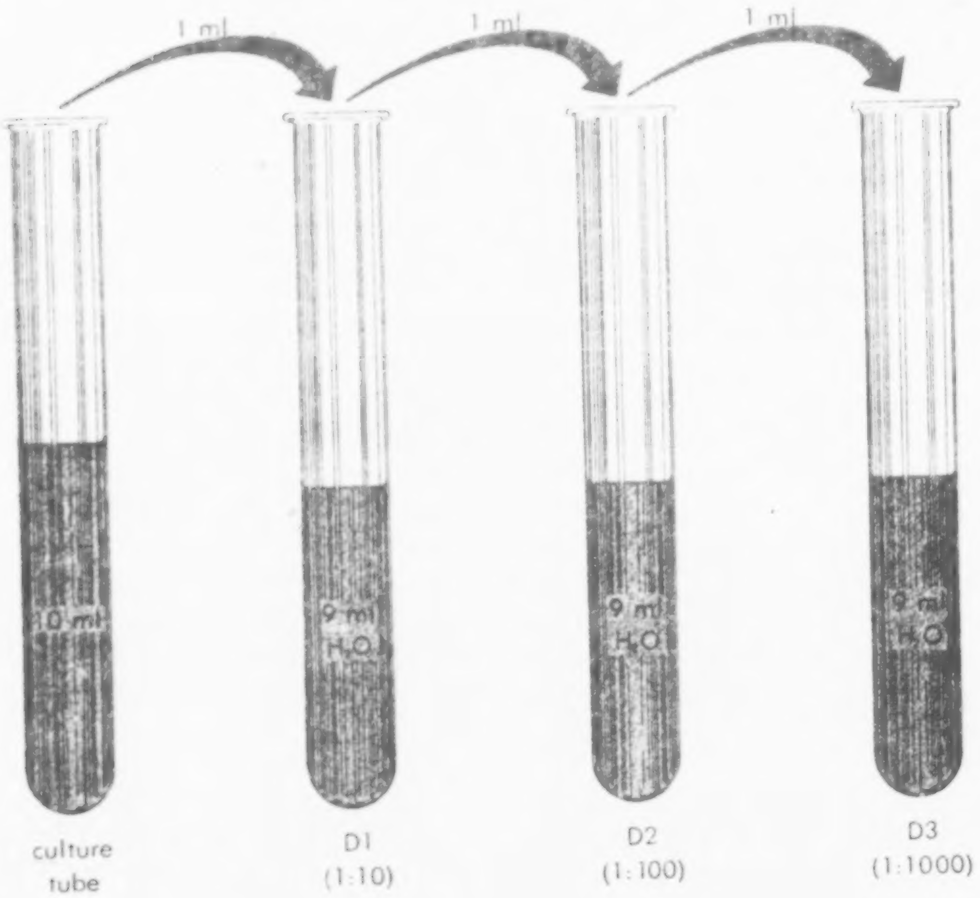


Figure 3

As soon as you have finished recording the data, total the counts in each line of the two data forms. Then divide by 5 to get the average for the line. If, in any one tube, your average and your partner's average for the tube differ by more than 10 organisms, prepare new slides and repeat the counts.

One more job remains for each team: to make a count from a tube that has been incubated 0 days. This should be done by the pair that finished first (or as assigned by the teacher). Put a grain of dry yeast into the test tube containing 10 ml. of medium. Allow the tube to stand for 5 minutes, shaking occasionally. Proceed to count as directed above. The students who make this count will need to prepare an extra form in their data sheets.

STUDYING THE DATA:

You have already computed the figures for the "total" and "average" columns in the data forms. Now you need to compute the last column, "Average X Dilution Factor", and "Pair Average". The data for the last column is obtained by multiplying the average by the dilution factor. For example, if you made your count from Tube D2, the dilution factor is 100. If your average count was 15, then the number to be recorded in the last column is 1500. The pair average is obtained by averaging the two numbers in the last column of each form. The pair average for each tube will be recorded on a master form on the chalkboard. Here all the counts from all the teams will be brought together.

We have not counted the whole population in any of the tubes. We have obtained an estimate of the populations by a method called sampling. To increase the accuracy of our estimate, we have taken certain precautions. First, we shook the tubes in an attempt to distribute the organisms evenly through them. Second, we counted the organisms in 5 different fields of view. By averaging these, we tended to "smooth out" chance differences in the fields we counted. Third, two people made counts from the same tube, and we averaged their counts. Fourth, we averaged the differences between the figures obtained by all the teams, which further tended to smooth out chance differences between the tubes. What we finally have for the population of each period of incubation is a density expressed as average number of organisms per high power field of view.

Using ordinary graph paper, list the age of the cultures, in days, on the horizontal axis; list the density of the populations on the vertical axis. Plot the data from each team separately, using a different color for each team. Then use black to plot the averaged data of all teams. (1) On the basis of the discussion in the preceding paragraph, explain the similarities and differences among the graph lines.

CONCLUSIONS:

Compare the line drawn from the class average (black) with the line drawn on ordinary graph paper in the sparrow model. (2) In what ways are the lines similar? (3) In what ways are the lines different? (4) Keeping in mind the assumptions made in the previous sparrow exercise and the conditions under which your yeast populations lived, explain these similarities and differences. (5) Is the hypothesis confirmed?

Laboratory Problem

FACTORS LIMITING POPULATIONS

INTRODUCTION:

In the sparrow problem no environmental factors limited the growth of the house sparrow population. In the last exercise, however, at least two environmental factors limited the growth of the yeast population: the amount of food supplied in the medium and the waste materials that accumulated in the medium. For natural populations food supply is not unlimited, but neither is it a fixed quantity that cannot be renewed. To continue our study, we now need to examine the growth of a natural population.

PURPOSE:

The purpose of this exercise is to compare the growth of a natural population, first, with the growth of a laboratory population and second, with the growth of a hypothetical population.

MATERIALS:

ordinary graph paper, one sheet per student

PROCEDURE:

Gathering data on natural populations is always difficult. For our puposes here, it is not necessary that we gather the data ourselves. Instead we shall use data (gathered by Charles Elton, of Oxford University) on a natural population of English field mice. As is often the case in studying natural populations, the actual number present in the area studied is not known. The density is given as the average number of mice caught per 100 traps per night for one month. Thus, even in this real situation we have to make an assumption: that the actual density of the mice was always in proportion to the number of mice caught. The data are presented in Figure 1.

Months	Average Number of Mice Caught/100 Traps Per Night
May, 1927	1
June	1.3
July	2.3
August	3
September	6.5
October	3.2
November	2.5
December	2.3
Jan., 1928	6
Febuary	5.5
March	5
April	5.7

Figure 1.: Data on a Population of English Field Mice in a Woods Near Oxford, England

Plot the data on ordinary graph paper, using a vertical scale that will place the highest point for the population near the top of the graph.

STUDYING THE DATA:

Compare the graph of the English field mouse population with the ordinary graphs made in the two previous problem (sparrows and yeast). (1) What part of this graph is similar to the other graphs? (2) How does it differ from the graph of the hypothetical house sparrow population? (3) How can you explain the difference? (4) How does this graph of a natural population of field mice differ from your graph of the laboratory population of yeast? (5) How can you explain the difference? (6) Which of the three populations was an open population, that is, one in which immigration and emigration could occur?

CONCLUSION:

We can now try to draw some general conclusions from our three exercises on population. (7) Does the growth of a population tend to follow a basic pattern? If so, what are the characteristics of this pattern? (8) What is the chief difference between the graph of the hypothetical population of sparrows and the graphs of the two real populations? (9) How do you account for the difference?

FOR FURTHER INVESTIGATION:

1. Ring-neck pheasants (originally a European species) were introduced on Protection Island, off the coast of Washington State, in 1937. Counts of the population were made each spring and fall for the next five years. Figure 2 presents the data (derived from that published by A.S. Einarsen).

Year	Population Size in Spring	Population Size in Fall
1937	8	40
1938	30	100
1939	90	425
1940	300	825
1941	600	1520
1942	1325	1900

Figure 2: Data on the population of pheasants on Protection Island

Plot the data on ordinary graph paper. How can you explain the regular fluctuations shown on your graph? Now, using a pencil of a different color, connect all the points representing spring counts, skipping the fall counts. What does this line tell you about the population? Remembering that this is a natural population, what do you think the counts after 1942 might have shown if they had been made?

2. The heath hen was once a common bird along the Atlantic coast from New England to Virginia. By 1880 it had disappeared from all locations except Martha's Vineyard, an island off Cape Cod. Figure 3 shows the result of a careful study of this population by A.O. Gross.

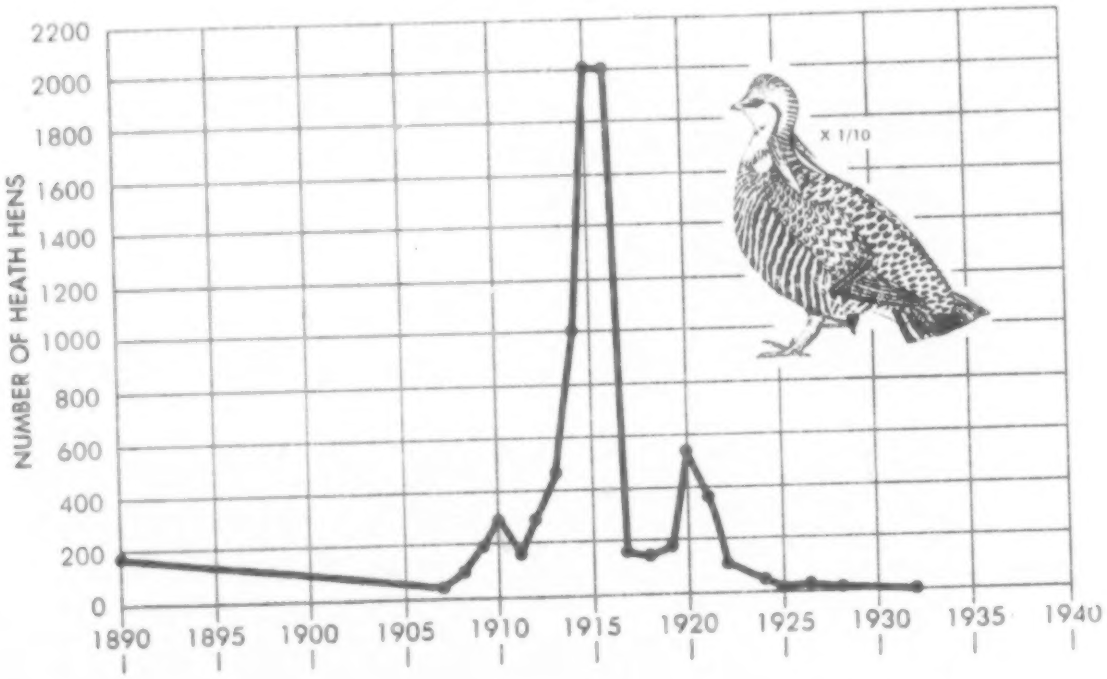


Figure 3.: Heath hen population on Martha's Vineyard, Massachusetts.

In what way is the part of this graph that shows the population before 1916 different from the "growth" part of the other graphs we have studied? Now we raise the question"What happened in 1907?" After you have thought about the question, refer to Chapman, F.M., Handbook of Birds of Eastern North America (New York: D. Appleton - Century Co., 1932), pages 241-242, for a possible explanation. What environmental factors does Chapman use to explain the history of the population after 1916? What term do we apply to a population that has reached the point attained by the heath hen population in 1932?

3. Figure 4 presents data collected by F.S. Bodenheimer on a population of Italian bees. Plot the data on ordinary graph paper. Does this graph resemble the graph for the house sparrow, the yeast, or the field mouse population most closely? On the bee graph, what is beginning to happen toward the end of the graph line? If you know something about bees, you should be able to tell what probably happened soon after the

collection of data was discontinued. Which of the population determiners mentioned in the text (BSCS Green Version, pages 28-29) is involved in the prediction you make?

DAYS	POPULATION OF COLONY (In thousands)
0	1
7	1.5
14	2.5
21	4
28	8
35	16
42	22
49	32
56	40.5
63	50.3
70	55
77	62.5
84	72
91	72.5
98	71
105	82
112	78
119	81

Figure 4.: Data on the population in a colony of Italian bees.

Review Questions

POPULATION STRUCTURE AND DYNAMICS

1. Why is the study of natural populations so difficult?

2. Of all organisms man has the greatest ability to influence his environment.

   a. In what ways do other organisms influence environments?

   b. Has man's influence been more negative than positive? Explain.

3. What causes populations to change in size?

4. In what ways would an increase in an organism's life span effect its population?

5. Are the Malthusian factors (war, pestilence and starvation) any threat to our expanding populations today? Could they be in the future? If yes, when?

6. Why do northern populations characteristically show regular and violent oscillations between abundance and scarcity?

7. Do any other organisms, other than man, undergo population explosions? Are the limiting and balancing factors the same for human populations as other populations?

8. What factors are involved in the evolution of Homo sapien populations?

9. Is it a "good thing" for the human population to continue to expand at its present rate indefinitely? If not, how can population explosions be controlled without serious restriction or loss of individual liberties and responsibilities?

10. If the human population is allowed to expand without restrictions, will it mean the extinction of many other species now present on earth?

11. What are the effects of crowding upon human behavior?

12. What steps are necessary to ensure adequate nutrition for all members of the human race?

PERIODIC CHART

Presented with the compli

SUBSHELLS BEI

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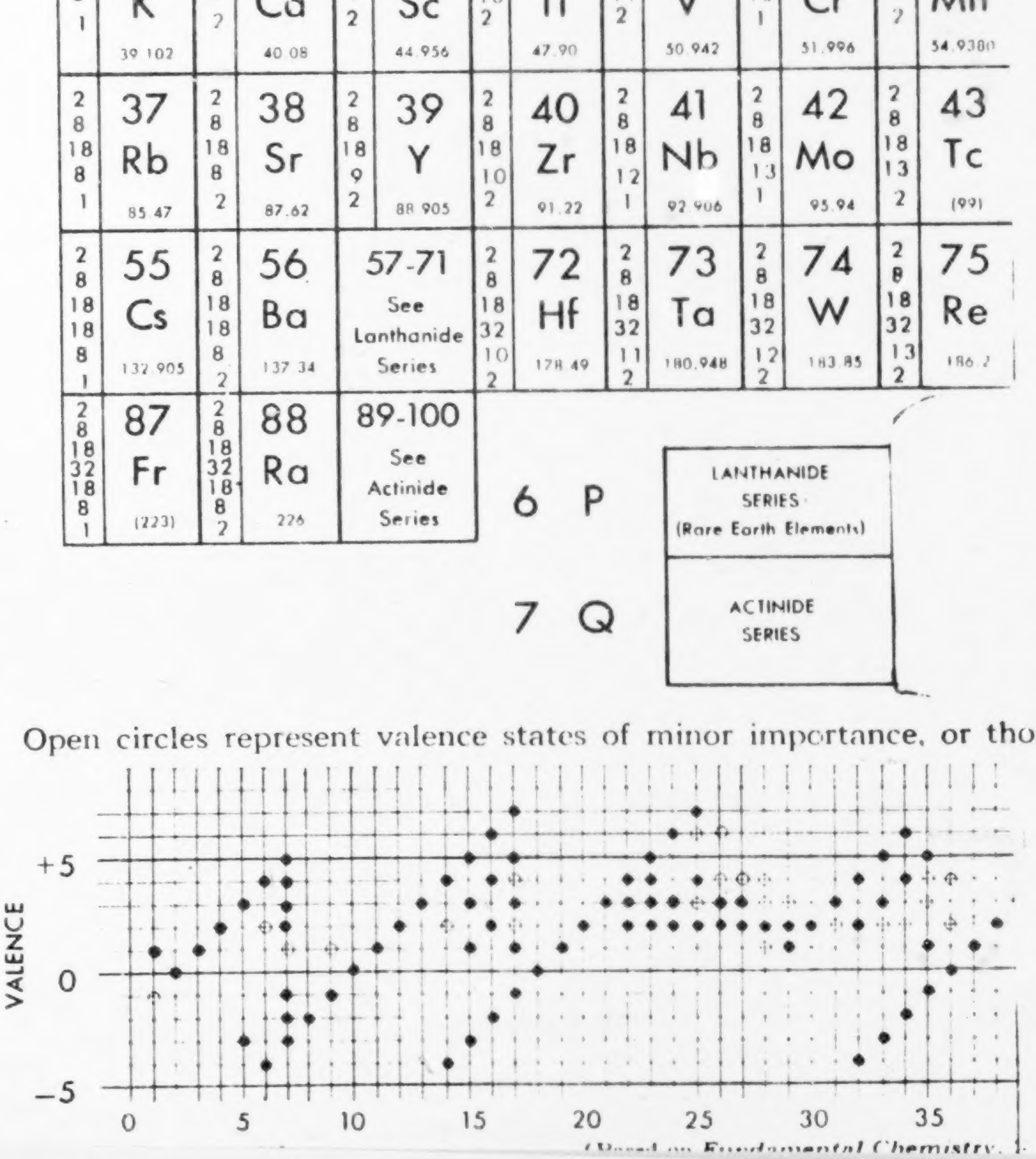
SHELLS PRINCIPAL QUANTUM No. *n*	X-RAY NOTATION	*LIGHT METALS* I A	*LIGHT METALS* II A	TRANSITION III B	IV B	V B	VI B	VII B
1	K	1 **1** H 1.00797						
2	L	2 1 **3** Li 6.939	2 2 **4** Be 9.0122					
3	M	2 8 1 **11** Na 22.9898	2 8 2 **12** Mg 24.312					
4	N	2 8 8 1 **19** K 39.102	2 8 8 2 **20** Ca 40.08	2 8 9 2 **21** Sc 44.956	2 8 10 2 **22** Ti 47.90	2 8 11 2 **23** V 50.942	2 8 13 1 **24** Cr 51.996	2 8 13 2 **25** Mn 54.9380
5	O	2 8 18 8 1 **37** Rb 85.47	2 8 18 8 2 **38** Sr 87.62	2 8 18 9 2 **39** Y 88.905	2 8 18 10 2 **40** Zr 91.22	2 8 18 12 1 **41** Nb 92.906	2 8 18 13 1 **42** Mo 95.94	2 8 18 13 2 **43** Tc (99)
6	P	2 8 18 18 8 1 **55** Cs 132.905	2 8 18 18 8 2 **56** Ba 137.34	**57-71** See Lanthanide Series	2 8 18 32 10 2 **72** Hf 178.49	2 8 18 32 11 2 **73** Ta 180.948	2 8 18 32 12 2 **74** W 183.85	2 8 18 32 13 2 **75** Re 186.2
7	Q	2 8 18 32 18 8 1 **87** Fr (223)	2 8 18 32 18 8 2 **88** Ra 226	**89-100** See Actinide Series				

6	P	LANTHANIDE SERIES (Rare Earth Elements)
7	Q	ACTINIDE SERIES

NOTE: A value given in parentheses denotes the mass number of the isotope of the longest known half-life, or of the best known one.

[*] The brackets are meant to indicate only the general order of subshell filling. The filling of subshells is not completely regular, as is emphasized by the use of red ink to denote shells which have electron populations different from the preceding element. In the case of He, subshell population is not by itself indicative of chemical behavior, and that element is therefore included in the *inert* gas group, even though helium possesses no p-electrons.

Open circles represent valence states of minor importance, or thos



OF THE ELEMENTS

REVISED, 1964

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NG COMPLETED*

p

HEAVY METALS

NON METALS

VIII	VIII	VIII	I B	II B	III A	IV A	V A	VI A	VII A	INERT GASES
										2 He 4.0026 2
					5 B 10.811 2 3	6 C 12.01115 2 4	7 N 14.0067 2 5	8 O 15.9994 2 6	9 F 18.9984 2 7	10 Ne 20.183 2 8
					13 Al 26.9815 2 8 3	14 Si 28.086 2 8 4	15 P 30.9738 2 8 5	16 S 32.064 2 8 6	17 Cl 35.453 2 8 7	18 Ar 39.948 2 8 8
26 Fe 55.847 2 8 14 2	27 Co 58.9332 2 8 15 2	28 Ni 58.71 2 8 16 2	29 Cu 63.54 2 8 18 1	30 Zn 65.37 2 8 18 2	31 Ga 69.72 2 8 18 3	32 Ge 72.59 2 8 18 4	33 As 74.9216 2 8 18 5	34 Se 78.96 2 8 18 6	35 Br 79.909 2 8 18 7	36 Kr 83.80 2 8 18 8
44 Ru 101.07 2 8 18 15 1	45 Rh 102.905 2 8 18 16 1	46 Pd 106.4 2 8 18 18	47 Ag 107.870 2 8 18 18 1	48 Cd 112.40 2 8 18 18 2	49 In 114.82 2 8 18 18 3	50 Sn 118.69 2 8 18 18 4	51 Sb 121.75 2 8 18 18 5	52 Te 127.60 2 8 18 18 6	53 I 126.9044 2 8 18 18 7	54 Xe 131.30 2 8 18 18 8
76 Os 190.2 2 8 18 32 14 2	77 Ir 192.2 2 8 18 32 15 2	78 Pt 195.09 2 8 18 32 17 1	79 Au 196.967 2 8 18 32 18 1	80 Hg 200.59 2 8 18 32 18 2	81 Tl 204.37 2 8 18 32 18 3	82 Pb 207.19 2 8 18 32 18 4	83 Bi 208.980 2 8 18 32 18 5	84 Po (210) 2 8 18 32 18 6	85 At (210) 2 8 18 32 18 7	86 Rn (222) 2 8 18 32 18 8

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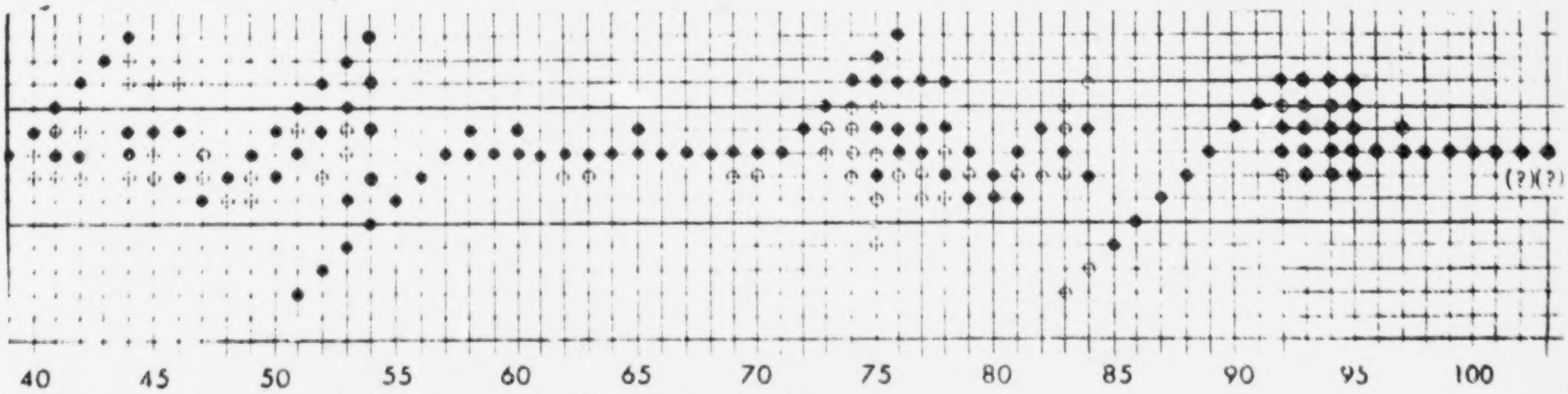
d	f													
57 La 138.91 2 8 18 18 9 2	58 Ce 140.12 2 8 18 19 9 2	59 Pr 140.907 2 8 18 21 8 2	60 Nd 144.24 2 8 18 22 8 2	61 Pm (147) 2 8 18 23 8 2	62 Sm 150.35 2 8 18 24 8 2	63 Eu 151.96 2 8 18 25 8 2	64 Gd 157.25 2 8 18 25 9 2	65 Tb 158.924 2 8 18 26 9 2	66 Dy 162.50 2 8 18 28 8 2	67 Ho 164.930 2 8 18 29 8 2	68 Er 167.26 2 8 18 30 8 2	69 Tm 168.934 2 8 18 31 8 2	70 Yb 173.04 2 8 18 32 8 2	71 Lu 174.97 2 8 18 32 9 2
89 Ac (227) 2 8 18 32 18 9 2	90 Th 232.038 2 8 18 32 18 10 2	91 Pa (231) 2 8 18 32 20 9 2	92 U 238.03 2 8 18 32 21 9 2	93 Np (237) 2 8 18 32 22 9 2	94 Pu (244) 2 8 18 32 23 9 2	95 Am (243) 2 8 18 32 24 9 2	96 Cm (247) 2 8 18 32 25 9 2	97 Bk (247) 2 8 18 32 26 9 2	98 Cf (251) 2 8 18 32 27 9 2	99 Es (254) 2 8 18 32 28 9 2	100 Fm (253) 2 8 18 32 29 9 2	101 Md (256) 2 8 18 32 30 9 2	102 No (254)	103 Lw (257)

unobtainable in presence of water. For transuranian elements, all valences reported are listed.



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